AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 49 No. 10 OCTOBER 1959 PRICE: 3s. 6d.

LEY'S
LEMAX
PEARLITIC
MALLEABLE
CASTINGS

Flame-hardened internal gear

This 'Lemax' casting, for a commercial vehicle planetary two-speed axle, combines the hardened internal gear with part of the differential housing.

The casting, which is 11 inches diameter and weighs 38 lb., meets the following specification:
Gear-teeth: flame-hardened.
Journal: induction hardened.
Min. tensile strength: 100,000 P.S.I.
Min. yield strength: 80,000 P.S.I.
Min. elongation in 2": 2%.

Regd. Trade Marks: 'Black Heart' 'Leys' 'Lepas' 'Lemax'
LEY'S MALLEABLE CASTINGS CO. LTD.
DERBY, ENGLAND · *Telephone:* Derby 45671

LEY'S

ECCO FOR EVERY KIND OF PAINT JOB

SPRAY GUNS

- **Lighter than any other guns of comparable performance.**
- **Single hand operation for fan and fluid controls.**
- **Streamlined for easy cleaning.**

ECCO 30 Made from tough, light aluminium alloy, this is the largest gun in the range. Five easily changed nozzles fitting on to one standard needle make it suitable for a wide range of paints and lacquers; two more nozzles are available for very high viscosity materials. Designed for top quality finishing with volume output, the Ecco 30 can be used with suction-feed cups or pressure-feed containers.

Other versions too! Fitted with a gravity cup the 30 becomes the 302. Amongst other uses it is the most suitable gun available for applying short 'pot-life' catalysed finishes where the cost of a production type catalyst unit is not justified.
The same needles, nozzles, aircaps and spares are used with the Ecco 30, and 302.

ECCO 303 Slightly smaller than the Ecco 30, but with identical spare parts, the 303 is suitable for pressure or suction-feed and is used where lower air pressures and volumes are required.

ECCO 307 The pressure fed 307 gives the operator in garage or production line the same rate of application and quality of atomisation with small quantities of material, at the viscosity used in quantity production.

ECCO 308 A heavy duty gun designed for spraying automobile undercoating, sound deadeners, sand and cement mixtures and all high viscosity material requiring nozzle diameters of 7-12 millimetres ($\frac{1}{4}$"-$\frac{1}{2}$"). Pressure fed from bottom outlet containers or pumps, the 308 will handle large quantities of materials.

For full details of Ecco Paint Spraying Equipment, contact your local Atlas Copco company or representative, or write to Atlas Copco AB, Stockholm 1, Sweden.

ECCO 307

ECCO 302

Atlas Copco

PUTS COMPRESSED AIR TO WORK FOR THE WORLD

8.22

HOLSET NON-BONDED RUBBER CRANKSHAFT DAMPERS

A combined torsional vibration damper and pulley offers a unit ready balanced and assembled, for immediate fitting to the engine crankshaft.
No other non-bonded damper offers this simplicity and proven reliability.

THIS NEW APPROACH MEANS —

INCREASED RELIABILITY AT REDUCED COST

BRITISH AND FOREIGN PATENTS PENDING

THE HOLSET ENGINEERING CO. LTD.
Turnbridge • Huddersfield

TELEPHONE: HUDDERSFIELD 7480 TELEGRAMS: HOLSET, HUDDERSFIELD

Hardy Spicer Ltd.

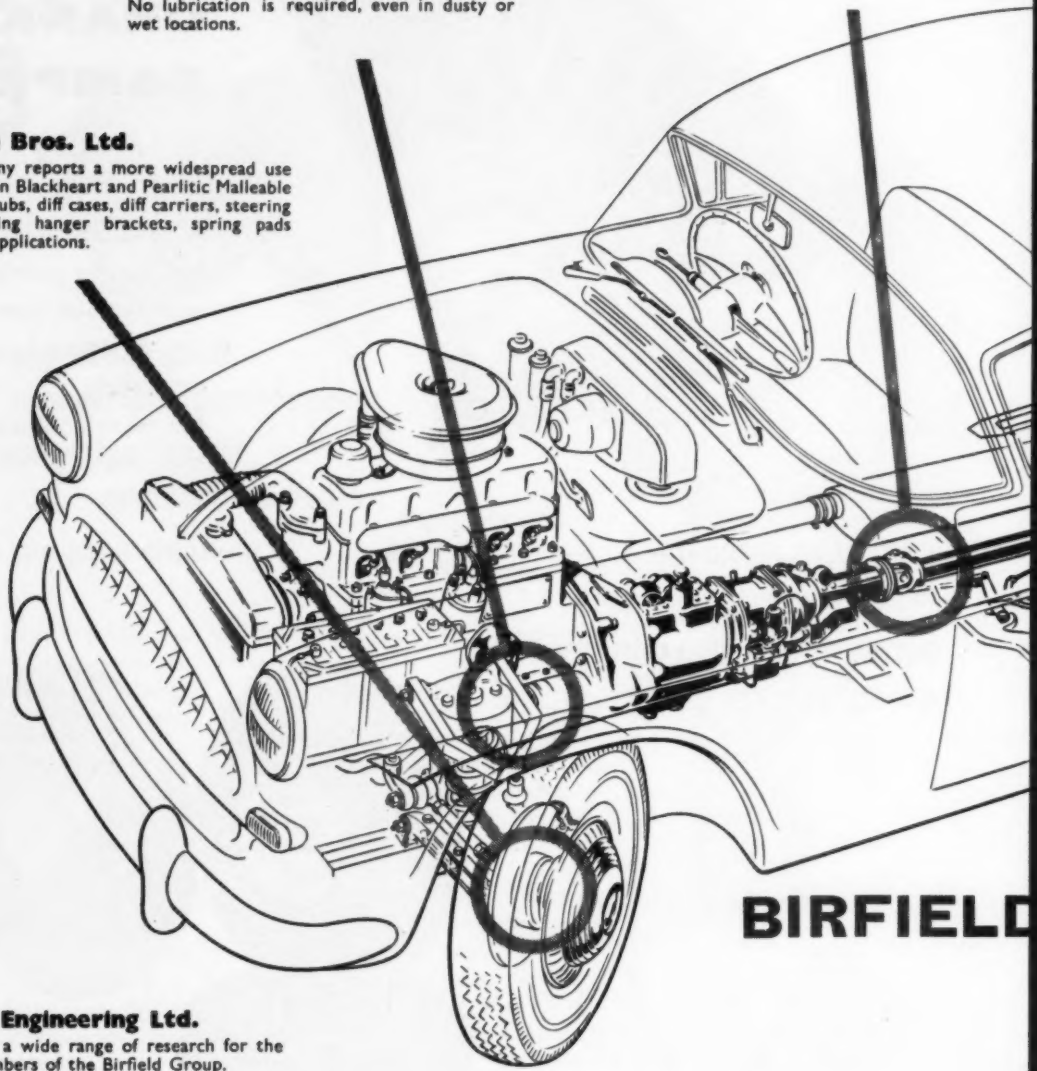
Progressive development has more than met the increasing demands from the Motor Industry. Whatever the future requirements of engineers and designers may be, the intensive research carried out by Hardy Spicer ensures that their propeller shafts and universal joints will be capable of meeting them.

Bound Brook Bearings Ltd.

Self-lubricated bearings for various linkage and electrical unit applications have been augmented by Polyslip bearings. These are P.T.F.E. impregnated, in sintered bronze with the addition of lead or molybdenum disulphide. No lubrication is required, even in dusty or wet locations.

Shotton Bros. Ltd.

The company reports a more widespread use of castings in Blackheart and Pearlitic Malleable for wheel hubs, diff cases, diff carriers, steering boxes, spring hanger brackets, spring pads and other applications.



BIRFIELD

Birfield Engineering Ltd.

Carries out a wide range of research for the various members of the Birfield Group.

The Phosphor Bronze Co. Ltd.

Manufacturers of bearing materials, clutch plates and S.G. iron castings.

Laycock Engineering Ltd.

Manufacturers of flexible couplings and propeller shafts, centre bearings, universal steering joints and the famous Laycock de Normanville overdrive—now available as an optional extra on over 30 British cars.

Intermit Ltd.

Manufacturers of filters for fuel pumps, carburettors, oil sumps, oil pumps and scuttle ventilators.

AUTOMOTIVE DIVISIO

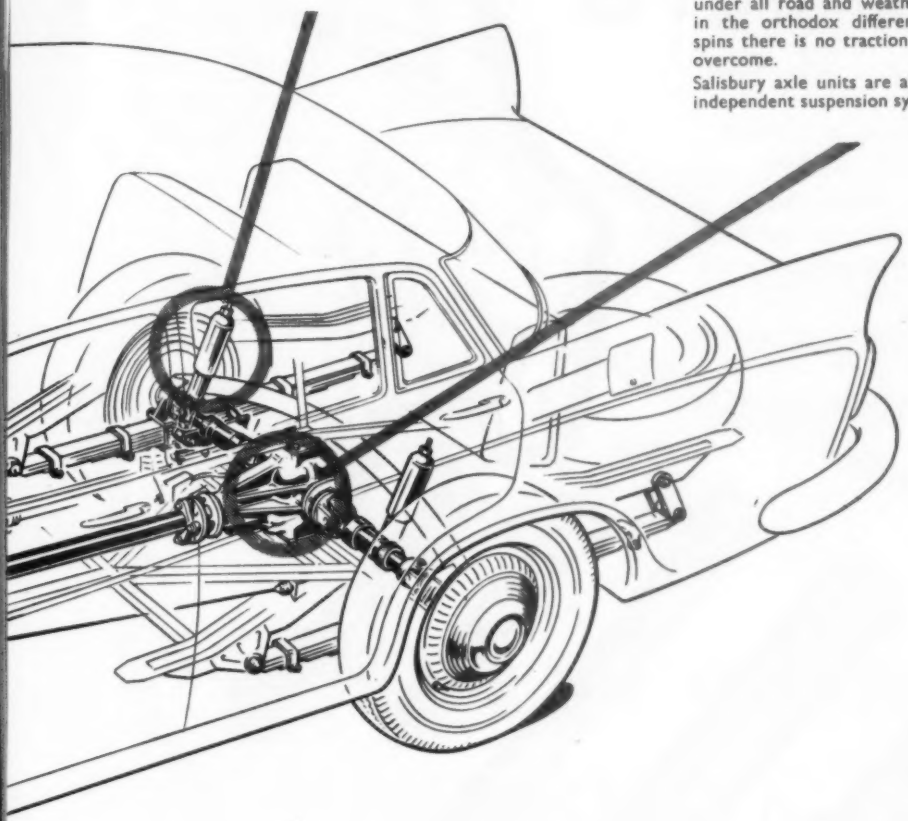
Forgings and Presswork Ltd.

The commencement of the manufacture of cold extrusions in steel makes possible the production of generally symmetrical parts to close tolerances. Many machining operations are avoided for such parts as shock absorber cylinders and power steering units.

Salisbury Transmission Ltd.

Included in new products are Powr Lok differentials which provide maximum traction automatically under all road and weather conditions. Deficiencies in the orthodox differential, where if one wheel spins there is no traction available at the other, are overcome.

Salisbury axle units are also being manufactured for independent suspension systems.



DEVELOPMENTS SET THE PACE

More Power, improved design and comfort . . . these have set the pattern for the enormous successes in the British automobile industry over the past year. The Automotive Division of the Birfield Group has played a big part in helping British motor car manufacturers to lead the world.

We shall be glad to meet you on the Birfield Group* STAND 375-379 *on the first floor, AVENUE "L."

	STAND		STAND
THE PHOSPHOR BRONZE CO. LTD.	375	LAYCOCK ENGINEERING LTD.	378
SHOTTON BROS. LTD.	375	HARDY SPICER LTD.	379
FORGINGS AND PRESSWORK LTD.	376	BOUND BROOK BEARINGS LTD.	330
SALISBURY TRANSMISSION LTD.	377		Avenue "F"

BIRFIELD INDUSTRIES LIMITED

STRATFORD HOUSE · LONDON W.1. · GROSVENOR 7090

AUTOMOBILE PARTS

APN

We are specialists in the manufacture of precision and standard fasteners for the Motor Industry

NEWALLOY - Wheel Bolts, Wheel Studs.

NEWALLASTIC - Cylinder Head Studs and Bolts, Connecting Rod Bolts, etc.

NEWALLEX - Induction hardened Spring Shackle Pins and Bolts.

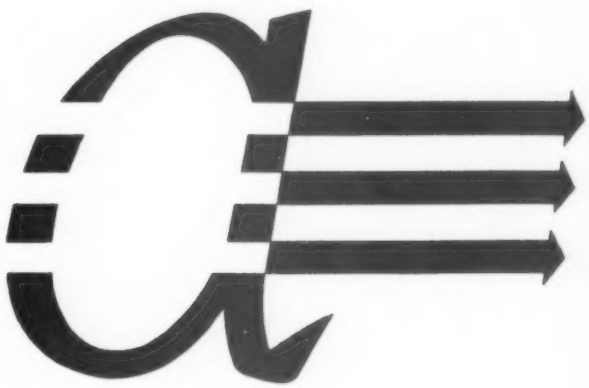
Standard bolts and nuts supplied in "R", "T", and "V" quality, and other Alloy Steels.

Group of typical components, as supplied to the leading motor car manufacturers.

A.P.Newall

AND COMPANY LIMITED

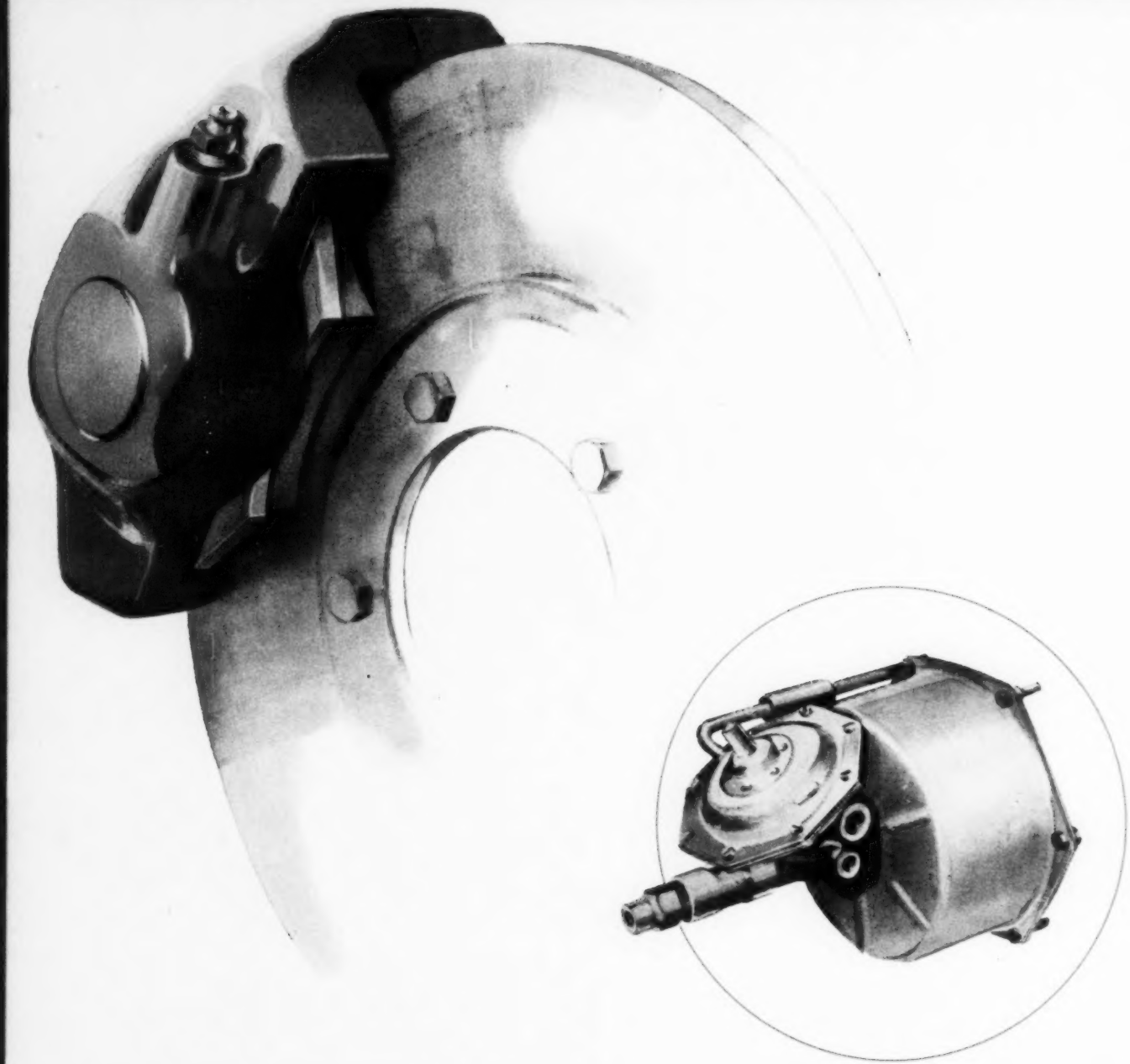
POSSILPARK · GLASGOW N.2.



This is the symbol of

THE AUTOMOTIVE PRODUCTS GROUP

Component specialists to Britain's Motor Industry



LOCKHEED DISC

Regd. Trade Mark : LOCKHEED.

OUTSTANDING ADOPTION OF LOCKHEED DISC BRAKE SYSTEM

Conforming to our policy, followed since the inception of our hydraulic brakes, we conducted a considerable amount of research, exploring different types of disc brakes and their detail design, and ultimately focused our conclusions upon one basic design.

This design, adaptable to suit the disc brake requirements of individual cars, has been adopted in one or other of its variants by Britain's biggest car manufacturers, and by specialists producing sports cars.

STABILITY & HIGH PERFORMANCE

Lockheed disc brakes, made to the same high standards of material and workmanship as the drum brakes that have made Lockheed famous, develop to the full the qualities of stability and high performance that are characteristic of the disc brake at its best. The brakes are self-adjusting.

HIGH-VOLUME PRODUCTION

The basic simplicity, characteristic of Lockheed productions, permits high-volume manufacture combined with close limits and strict interchangeability.

THE LOCKHEED POWER BRAKING UNIT (*shown on left*)—
the best of its kind—is available in two sizes, to suit all cars.

BRAKES

WOLSELEY
6-99

AUSTIN
A-99

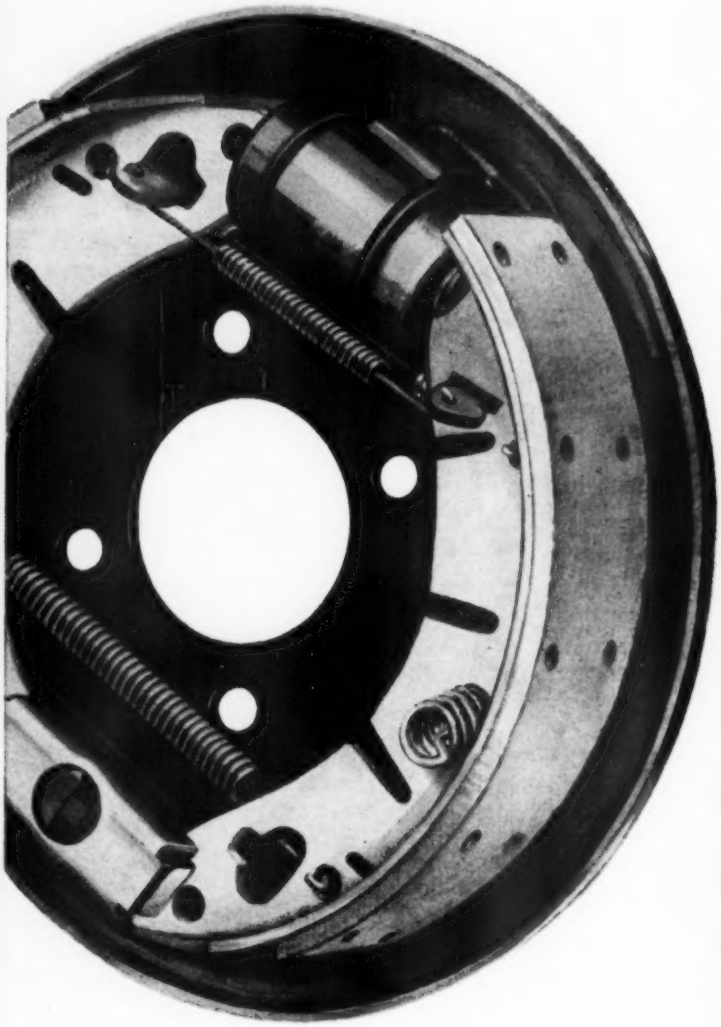
MGA
1600

ALVIS
3 LITRE

SUNBEAM
RAPIER

NEW IMPROVED DRUM BRAKES

This new series of brakes embodies the outstanding features of previous Lockheed brakes with, in addition, some valuable detail improvements. These brakes are made in four sizes; 7″, 8″, 9″ and 10″. The 7″ has leading and trailing shoes for all wheels; the 8″, 9″ and 10″ have two leading shoes on the front, and leading and trailing shoes on the rear. The drawing shows a rear brake. The wheel cylinder is fixed to the backplate and has two opposed pistons and improved sealing arrangements.



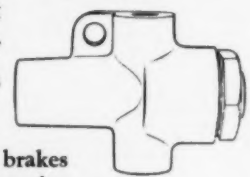
HAND-BRAKE LEVER SUITS I.R.S.

The separate hand-brake lever is arranged to suit either fore-and-aft or transverse travel, thus conforming to the requirements of I.R.S., and has improved booting.

EXTERNAL SHOE ADJUSTMENT

A change in detail design permits shoe adjustment from behind the backplate on front and rear brakes. Other features of these brakes include interchangeability of all eight brake shoes.

The Lockheed pressure-limiting valve, shown here, can be used with disc or drum brakes and is most effective in controlling the share contributed by the rear-braking system on cars in which weight distribution or transfer is such as to make its use desirable.



Lockheed light mechanical brakes are also made in a wide range for various uses including trailers and caravans.

LOCKHEED BRAKES

ONE OF THE AUTOMOTIVE PRODUCTS GROUP

Regd. Trade Mark: Lockheed

LOCKHEED HYDRAULIC BRAKE COMPANY LTD
LEAMINGTON SPA. WARWICKSHIRE

SOME OF THE NEW DEVELOPMENTS OF BORG & BECK

7¼" 'DIAPHRAGM' TYPE RACING CAR CLUTCH

This triple-plate clutch, designed expressly for competition and racing use, has the following special features:

High torque capacity.

Suitability for high r.p.m.

Low inertia driven plates.

Small overall dimensions and light weight.

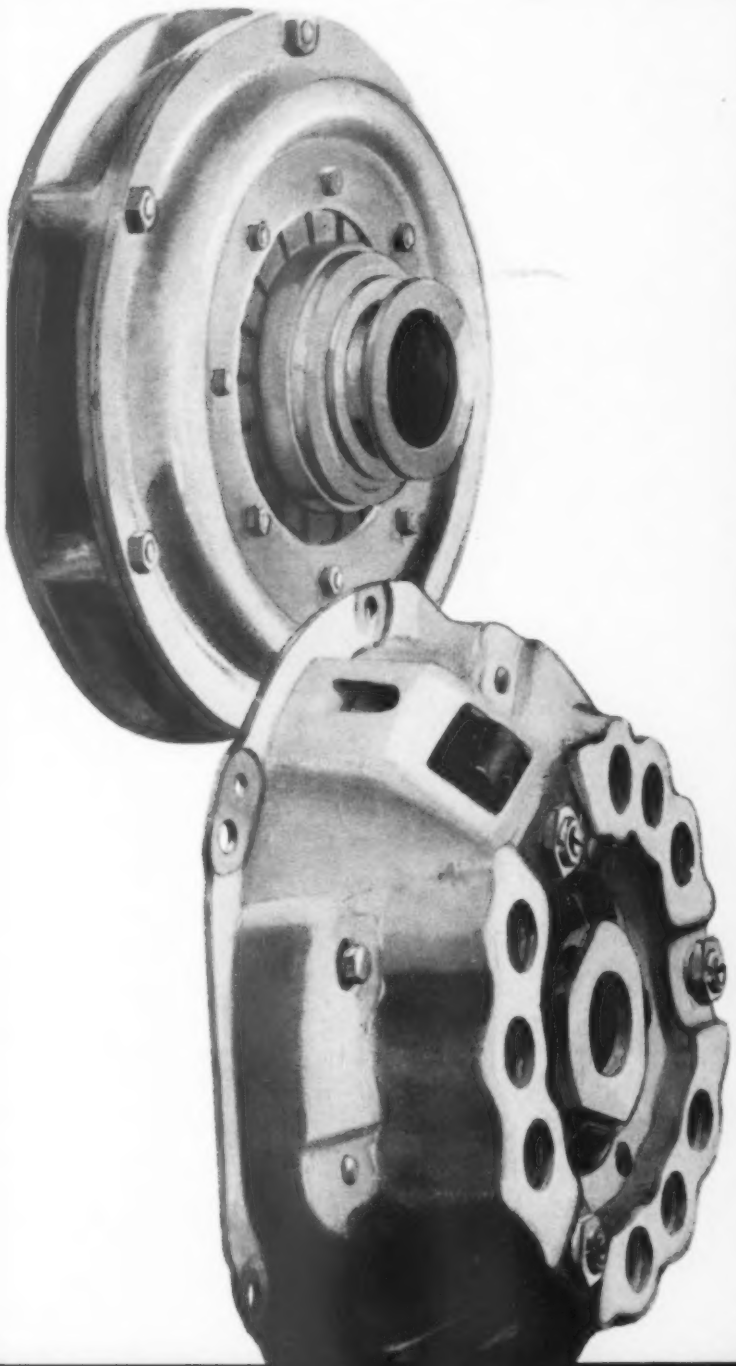
Ability to operate at high temperatures.

Available with either 1, 2, 3 or 4 driven plates.

Interchangeable as a unit with twin and triple plate Borg & Beck clutches previously used for racing.

8" AND 8½" STRAP DRIVE CLUTCH

This clutch embodies the successful self-centring frictionless strap drive to the pressure plate. The clutch can be installed in the same size bell housing used with the standard Borg & Beck 8" A.6 clutch, and the same types of flywheel and release bearing can be used. According to the nature of the application, the clutch can be used with either an 8" or an 8½" driven plate.

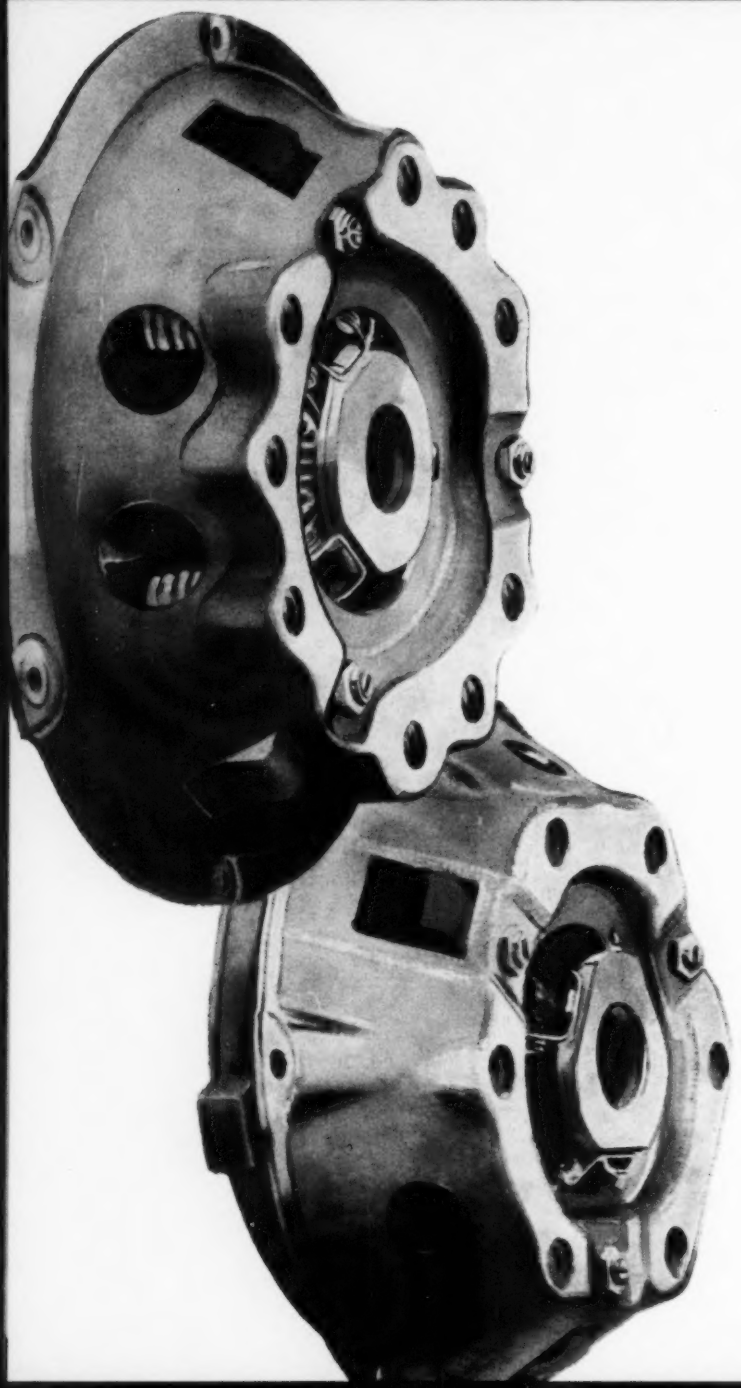


BORG & BECK CLUTCHES

Regd. Trade Mark: Borg & Beck

BORG & BECK COMPANY LIMITED
LEAMINGTON SPA. WARWICKSHIRE

ONE OF THE AUTOMOTIVE PRODUCTS GROUP



THE BORG & BECK STANDARD RANGE

These car clutches range from $6\frac{1}{4}$" to 11", in addition to the range of commercial vehicle clutches. These clutches are used on more than 80% of Britain's cars.

THE $7\frac{1}{4}$" TWIN-PLATE CLUTCH

To meet the present-day requirements for a clutch of high torque capacity within a small overall diameter, and suitable for higher rotational speeds, the $7\frac{1}{4}$" twin-plate clutch has been evolved. (*shown at top*).

It follows normal Borg & Beck design, with a pressed steel cover and knife-edged struts for the release lever. It has two driven plates: it is of interest that the driven plate inertia is less than that of a single plate of equivalent capacity, reducing the loads on the synchromesh clutches and assisting rapid gear changes. The clutch has a high torque capacity and is suitable for medium-high engine speeds. The driven plates can be the normal Borglite driven plates with organic facings for normal passenger cars, or rigid plates with sintered facings, for sports racing cars. The flywheel is recessed to take the second pressure plate, permitting the use of standard Borg & Beck parts.

Borg & Beck clutches are operated by mechanical, or by Lockheed hydraulic, control.

BORG & BECK CLUTCHES

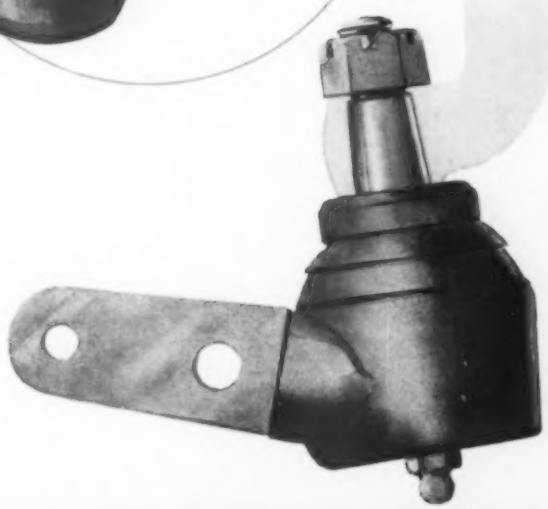
ONE OF THE AUTOMOTIVE PRODUCTS GROUP

A WIDE RANGE OF STEERING AND SUSPENSION JOINTS

Thompson self-adjusting steering joints eliminate backlash, reduce friction and provide long trouble-free life.

They are available in a wide range of sizes, for vehicles of all sizes, and for use on side rods, centre rods, drag links and tie-rods.

In addition to the standard range there are self-lubricating types which eliminate maintenance during the life of the car.



THOMPSON SUSPENSION JOINTS

simplify steering and suspension layouts and obviate the need for adjustment.

Thompson BALL JOINTS

Regd. Trade Mark

AUTOMOTIVE PRODUCTS COMPANY LTD
LEAMINGTON SPA. WARWICKSHIRE

ONE OF THE AUTOMOTIVE PRODUCTS GROUP

FULL FLOW FILTRATION OF ENGINE OIL

Purolator 'Micronic' full-flow filters have proved to be of the greatest value in protecting engines against oil-borne abrasives, and their use is greatly extending.

Their high efficiency is due to the plastic-impregnated paper element, pioneered by Purolator, which provides a great area of filter surface of closely controlled texture.

PUROLATOR 'MICRONIC' AIR FILTERS

Purolator also pioneered the 'Micronic' air filter and its use on motor car applications.

Considerable experience has been obtained therefore as to the size and capacity necessary to give a satisfactory performance without affecting either fuel consumption or power, when operating in various dusty localities throughout the world.

The dry type air filter has the following advantages:—

- ★ Positive filtration at all engine speeds
- ★ Complete engine protection regardless of operating conditions
- ★ Easy installation and simple, quick element servicing
- ★ Economical and weight saving

Regd. Trade Marks: Purolator, 'Micronic'

PUR LATOR

'MICRONIC' FILTERS

AUTOMOTIVE PRODUCTS COMPANY LTD.
LEAMINGTON SPA. WARWICKSHIRE

ONE OF THE AUTOMOTIVE PRODUCTS GROUP

a six-spindle machine occupying the floor space of a two-spindle machine

—the NEW HERBERT TURRET-TYPE DRILLING MACHINE

All operations performed at one setting of both component and machine.

Drills up to $\frac{7}{8}$"; taps up to $\frac{3}{4}$" Whit. A.C. current only.

ALFRED HERBERT LTD., COVENTRY

AD. 537

MOTOR SHOW
STAND No.
459

PERFECT ATOMISATION

FASTER FINISHING

LIGHTER WEIGHT

FATIGUE-FREE PISTOL GRIP

£9-6-9

27

A.I.D. MODEL

the spray gun for your industry

This universal spray gun has every advantage a spray gun can offer. It will cope with liquid of any viscosity and has a range of nozzles to suit every need. It has been kept short to assist spraying inside a small radius or restricted space. Compare it with any other gun of its class and you'll soon discover why the A.I.D. 27 is fast becoming the first favourite of industry. Fully descriptive literature is available on request.

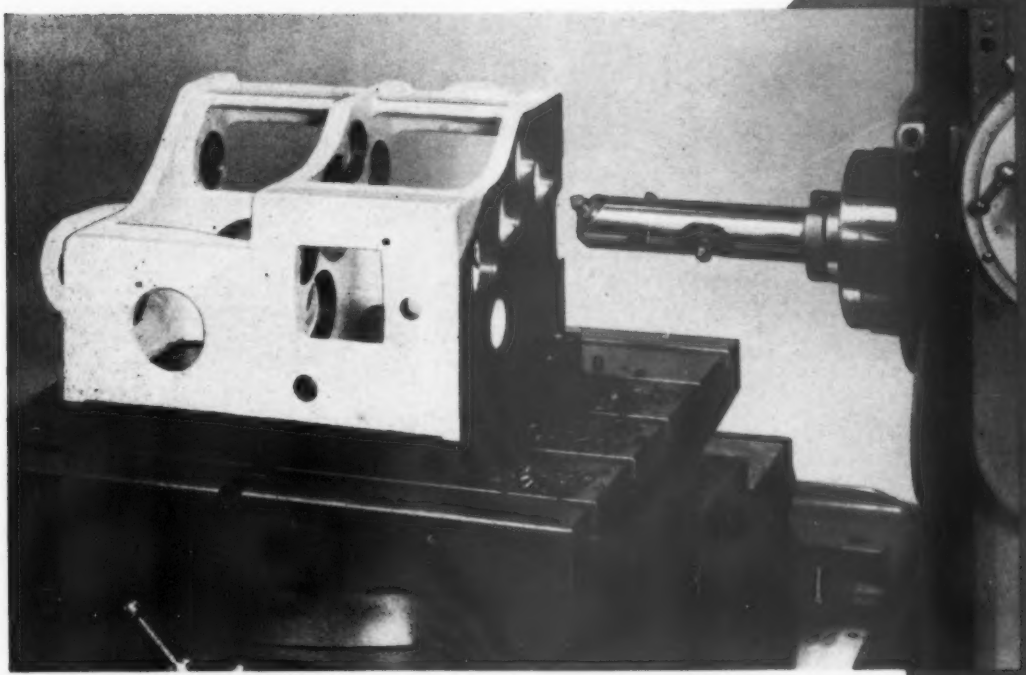
AIR INDUSTRIAL DEVELOPMENTS LTD

Aidspray Works - Shenstone - Nr. Lichfield - Staffs - England
Phone: Shenstone 341/5 Grams: Aidspray, Shenstone
Canadian Office: 4 Lailey Crescent, Willowdale, Ontario BA 1.2677

machining from four sides at ONE SETTING

on a **HERBERT-DEVLIEG**

Spiramatic Jigmil



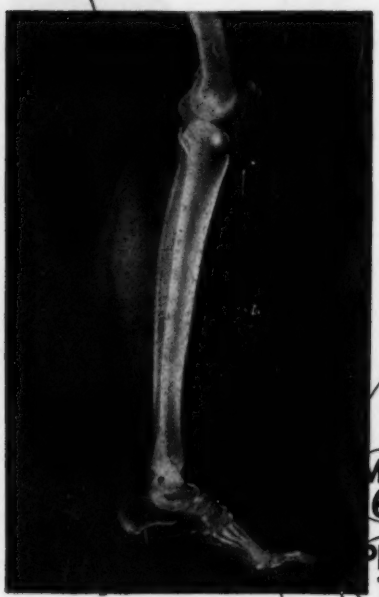
A cast-iron gearbox set-up on the index table of a DeVlieg 2B-36 Jigmil for rough and finish boring 13 holes (most holes are also faced and/or counter bored) ranging in size from 1·850″ to 2·8335″ diameter. Limits are ·0002″ on hole spacing and ·0005″ on diameter. Precision indexing of the table permits in-line boring and complete machining in one setting. Floor-to-floor time 1 hour 45 minutes.

The DeVlieg No. 2B-36 is the smallest of the range and is built in this country in a specially-equipped plant.

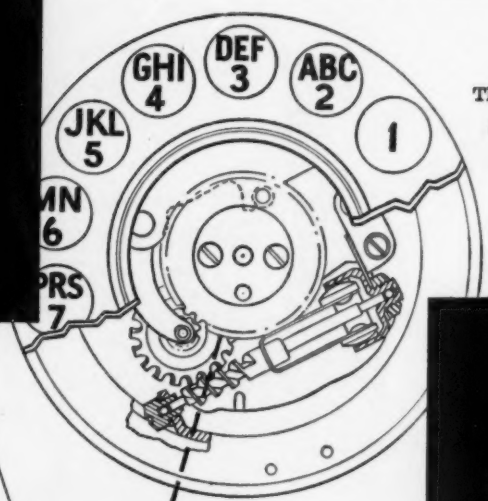
ALFRED HERBERT LTD., COVENTRY Factored Division, Red Lane Works.

AD.485

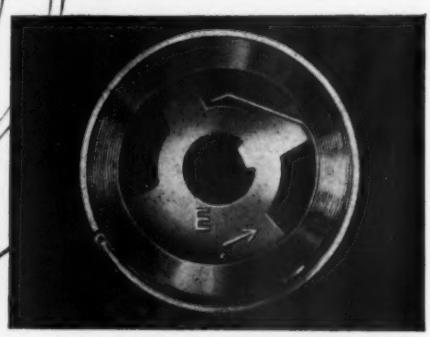
Vital links in controlled movement



A body needs muscles to control movement in very much the same way as a mechanism needs springs. These vital links take the stress and strain of every day rigorous use — nature provides the muscles . . . SALTER provides the springs. Two centuries of experience and development in the manufacture of springs of every type have enabled us to keep ahead of the ever-changing requirements of industry.



The applications for SALTER springs are wide and varied — from heavy machinery to finely balanced instruments..



By courtesy of Ericsson Telephones Limited.

For springs with the highest reputation and top performance specify SALTER all-action springs.

SALTER ESTABLISHED 1760

GEO. SALTER & CO. LTD
WEST BROMWICH
ENGLAND

...With the compliments of

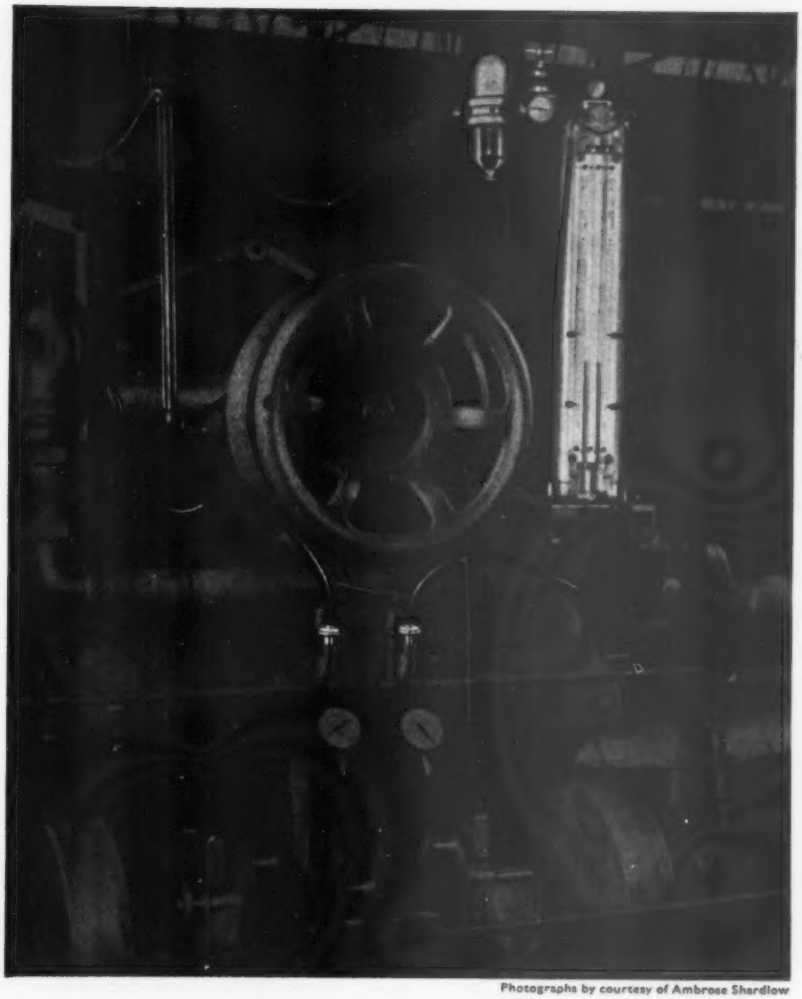
DORMER

THE SHEFFIELD TWIST DRILL AND STEEL COMPANY LIMITED

SHEFFIELD ENGLAND

DORMER TOOLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS

WITHSTANDS HIGH PRESSURE
SHOCK RESISTING
WEAR RESISTING
Oilite
Oilite
SELF-LUBRICATING BEARINGS AND POWDER METAL PARTS
THE MANGANESE BRONZE & BRASS CO LTD Elton Park Works Hadleigh Rd Ipswich · Grams: Oilite Ipswich · Tel: Ipswich 55926

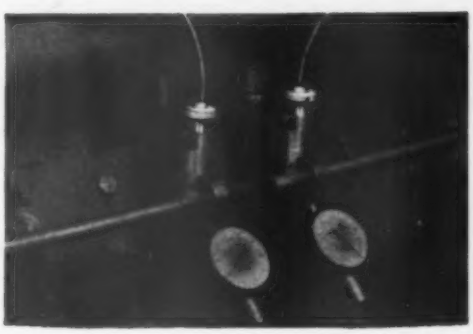


Photographs by courtesy of Ambrose Shardlow

Simple to use... Supremely accurate...

SOLEX air-operated external caliper grinding equipment

SHOWN here in use on automobile crankshafts, Solex External Caliper Grinding Equipment gives a direct reading uninfluenced by diminution on the average size of the part. This supreme accuracy is combined with extreme simplicity, and correct readings can be taken even by an unskilled operator. Twin crank pin diameter to tolerance .0005".



SOLEX have the measure of things

SOLEX (GAUGES) LTD 72 CHISWICK HIGH ROAD LONDON W4 Chiswick 4815

The problem

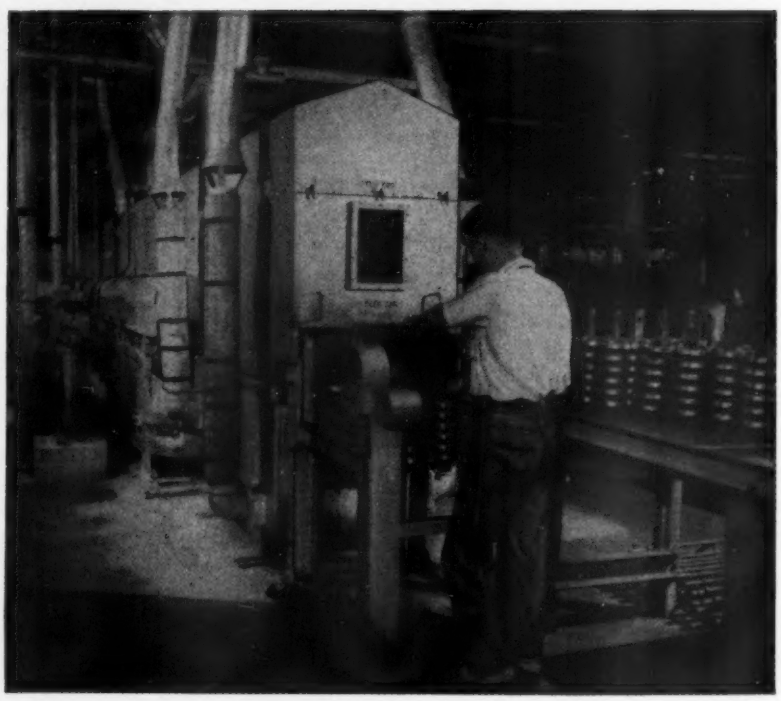
set by
THE HOFFMANN MANUFACTURING COMPANY LTD

To harden 10,000 ball and roller races per day, uniformly, with minimum distortion and a clean, scale-free finish.

the answer

given by the 'Cassel' Heat Treatment Service

A specially designed 'Cassel' continuous automatic martempering plant handles the required output. The ball and roller races, after being placed on jigs to separate them from each other, are martempered. This process reduces distortion and leaves a clean, scale-free finish. For advice on heat-treatment write to :



ICI **IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1**

CC197

THE *ALL-NEW* ANGLIA by FORD

As major suppliers of rubber/metal units,
Silentbloc Ltd. and their subsidiary,
Andre Rubber Company Ltd.,
are proud to be associated
with the ALL-NEW ANGLIA,
and wish Ford Motor Company Ltd.,
every success
with this impressive new model.

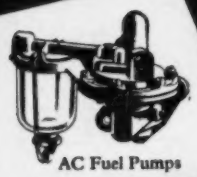
SILENTBLOC

VISIT US ON
STAND 323
AT THE MOTOR SHOW

ANDRE RUBBER

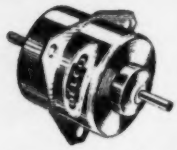
SILENTBLOC LIMITED MANOR ROYAL CRAWLEY SUSSEX
ANDRE RUBBER COMPANY LIMITED KINGSTON BY-PASS SURBITON SURREY

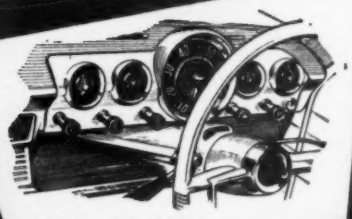
AC Air Cleaners & Silencers


AC Fuel Pumps

AC Oil Filters

AC Thermostats


DELCO Electric Motors


AC Instrument Panels

DELCO-REMY Oil-Filled Coils

Virtually every British vehicle has one or more AC-Delco products designed into it at drawing board stage. AC-Delco research engineers will gladly help when you are planning a new design or modifying an existing one.

These are a few in the wide range of AC-DELCO automobile and electrical products.

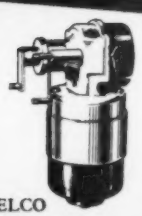
AC · Delco · Delco-Remy are registered trade marks

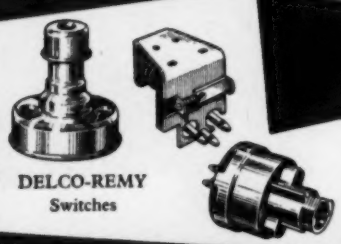
a good vehicle starts with

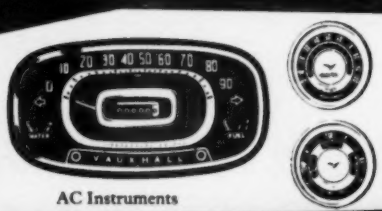
AC-Delco QUALITY PRODUCTS

AC Hot Tip Spark Plugs

DELCO-REMY Ignition Distributors

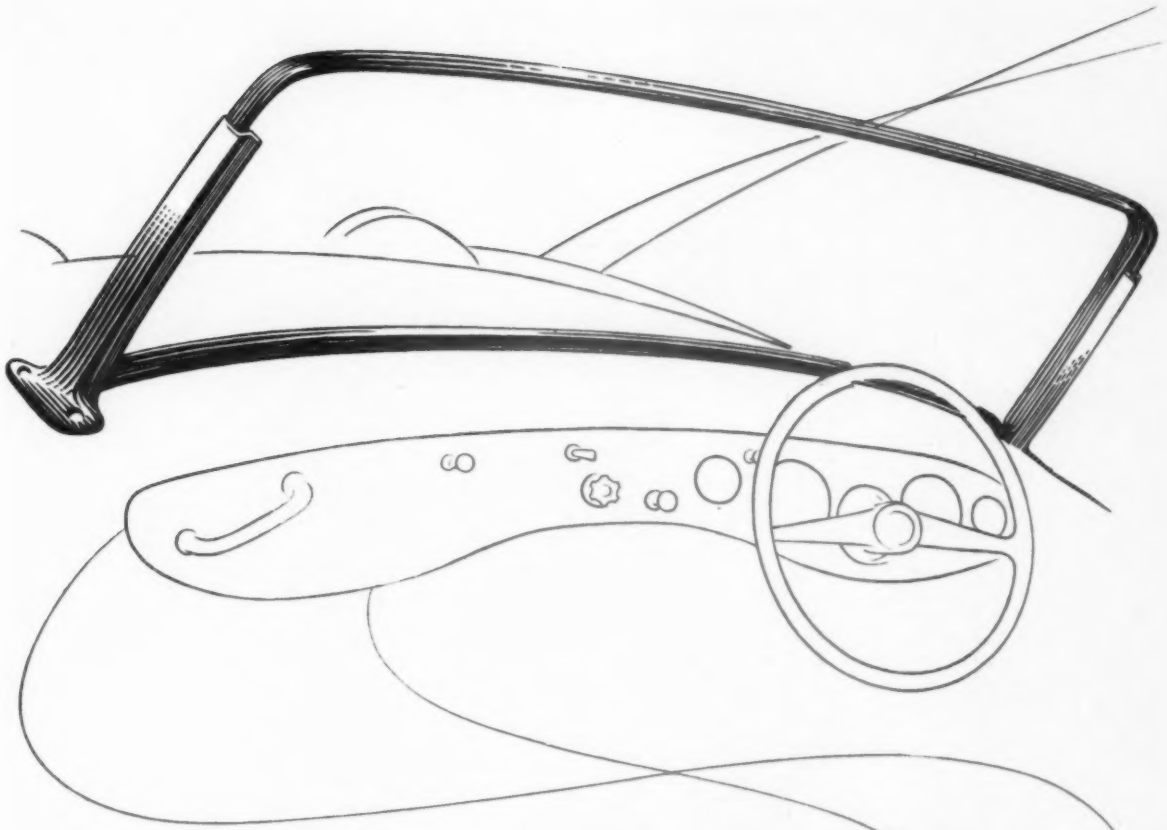

DELCO Electric Screen Wipers


DELCO-REMY Switches



AC Instruments

DELCO-REMY Electric Horns



CLEARLY it's **BIRMABRIGHT**

Take a look at the lively little Sprite and you can clearly see the designer's choice of Birmabright aluminium alloy for the windscreen surround. This up-to-the-minute light alloy is so easy to fabricate — yet so very strong. It looks good too, and its resistance to corrosion means that Sprite owners never need fear trouble at this vulnerable point.

Many foresighted manufacturers are turning to Birmabright for grilles, surrounds and trim. Are you?

Birmabright

Corrosion-resisting aluminium alloy

Windscreen surround, patented and fabricated by Weathershields Ltd., as fitted to the Austin Healey Sprite. Bright anodising by Charles & Watkins Ltd.

BIRMABRIGHT LIMITED · WOODGATE WORKS · BIRMINGHAM 32

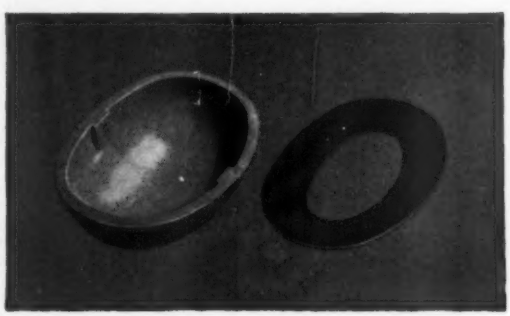
BM236

Here's a typical example of how the mechanical strength of Beetle D.M.C. (Dough Moulding Compound) helps to solve industrial problems.

These ear defenders are used to protect the hearing of workers in proximity to jet engines and in noisy factories. During the development work by the makers, Dennis Ferranti Meters Ltd., twelve sets moulded from conventional materials were delivered to Bomber Command for testing. The report of The Central Medical Establishment, Acoustics Laboratory, was that the ear defenders gave excellent protection, but that the mouldings then used were considered too fragile.

D.M.C. mouldings were substituted and have been found virtually indestructible.

D.M.C. is the ideal material whenever high mechanical and/or electrical strength is required. The material can be moulded in conventional compression presses on short cure times and at low pressure. We shall be glad to send full technical details.



This illustration shows the main moulding from Beetle D.M.C. and a retaining piece made from Scarab material. The Earguards are used in engine testing, rivetting, blasting, rolling mills, weaving sheds, paper mills and on aerodromes.

B·I·P

BEETLE MOULDING POWDERS

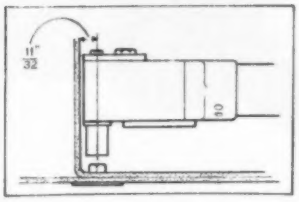
B.I.P. CHEMICALS LTD., Oldbury, Birmingham. Telephone : Broadwell 2061.
London Office: 28, Haymarket, S.W.1. Telephone: Trafalgar 3121

Picture of a man doing his nut

Rotten, isn't it, mate? You would have thought those gentlemen who sit on rubber cushions all day thinking beautiful thoughts would have put the nuts and bolts where people like you can get at them. But no, mate. Not they. Know what we'd do, mate, if we were in your position? We'd call in Desoutter quick and have a word with our medical advisers before it's too late.

Desouttability for purpose

DESOUTTER PNEUMATIC & ELECTRIC POWER TOOLS



A particularly Desouttable tool is the Type P201 Corner Nutrunner which gets into awkward corners within 11/32" of the vertical face.

DESOUTTER BROTHERS LTD., THE HYDE, HENDON, LONDON, N.W.9. TELEPHONE: COLINDALE 6346.

CRC319

"This is a job for Coopers"

And it is in the design stage when the COOPER technicians can be of the greatest assistance. It is their business to know all there is to know about Filters and Strainers. They are prepared to design and manufacture to your own specific requirements.

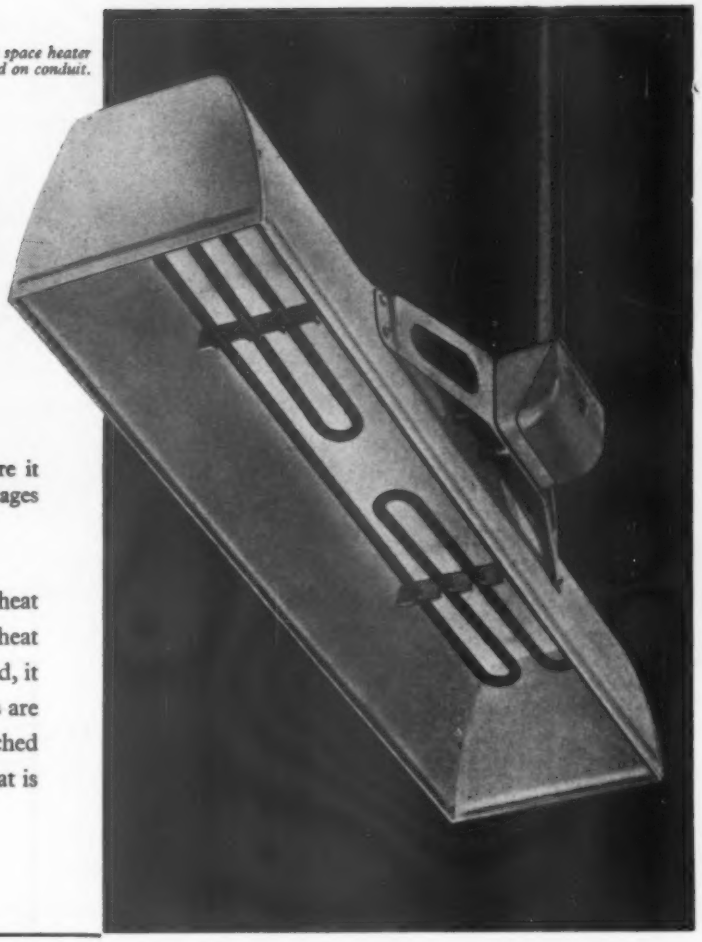
COOPERS engineers are available for consultation at all times.

COOPERS

AIR CLEANERS · STRAINERS · FILTERS · GASKETS
WASHERS · LAMINATED SHIMS · PRESSWORK

COOPERS MECHANICAL JOINTS LTD., LLANFOIST WORKS, ABERGAVENNY **Telephone: 1043-7**

A Metrovick radiant space heater suspended on conduit.

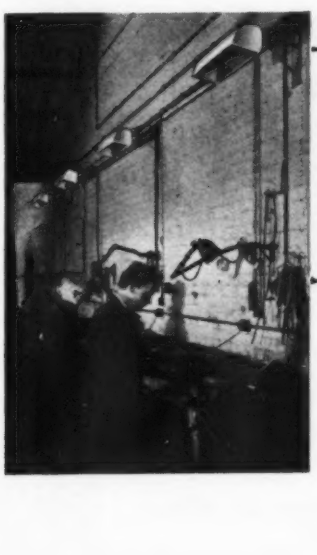


Warmth

projected where and when you want it!

Metrovick radiant space heaters project warmth where it is needed and for garage heating they offer many advantages over other forms of heating.

General space heating: Radiant heat does not heat the air but only the people or objects on which the heat rays fall, and where large garage areas are concerned, it is possible to heat just those areas where operatives are working. Heaters in unoccupied areas can be switched off until required. When they are required, the heat is available almost instantly.



Benches: In many garages, repair benches are located along the side walls. Space heaters can provide efficient local heating for the mechanics, impossible by other methods.

Petrol pumps, canopies, outside repair yards: The Metrovick space heater is the only weatherproof unit available. In locations where petrol vapour is likely, care must be taken in the siting of the units to avoid contravening Petroleum regulations.

Showrooms: Where a more attractive appearance is required than is provided by the strictly utilitarian industrial space heater, an ornamental bezel can be supplied in polished aluminium.

The Metrovick radiant space heater is available from stock in 1½ kW loading—£9.16.6 · 3 kW loading—£10.17.6

Associated Electrical Industries Limited
TRANSFORMER DIVISION — HEATING & WELDING DEPARTMENT
Trafford Park - - - Manchester 17

TGA L/1805

FRY'S body solders ensure non-porous jointing . . .

Body filling in modern car production is an important process. The solders employed must be smooth, free from zinc and other impurities. They must bond quickly with body pressings and cool without blemishes, pinholes or porosity.

For these reasons . . . .

Most British car manufacturers specify FRY'S

INSIDE INFORMATION

Photo-micrograph No. 1 shows the smooth characteristics of FRY'S top quality body solders, ABBEY and BELFRY. The regular constituent pattern gives rapid melting without impurities.

In photo-micrograph No. 2 the patchy irregular make-up denotes poor quality solder, causing gritty solder and porous joints.

PHOTO-MICROGRAPH 1. PHOTO-MICROGRAPH 2.

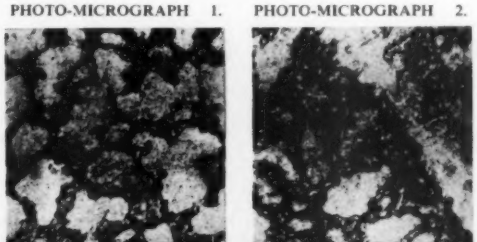


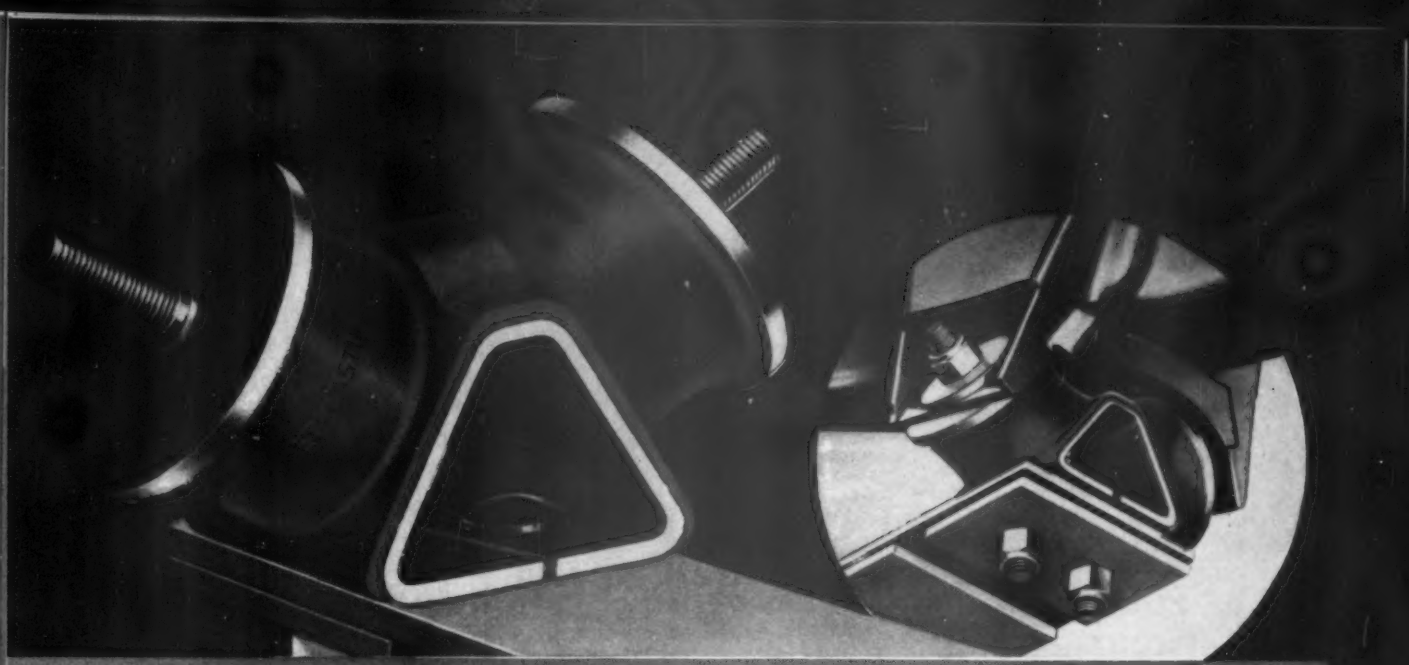
Photo-micrographs by FRY'S Research Laboratories.

FRY'S Metal Foundries Limited

Tandem Works, Merton Abbey, London, S.W.19 **Telephone: MITcham 4023 (7 lines)**

And at MANCHESTER · GLASGOW · KIDDERMINSTER · DUBLIN

MRP.100



METALASTIK CONTRASONIC
SPRING SHACKLES

PATENT APPLIED FOR

Isolating road noise

It is the *volume* of rubber that is the determining factor in isolating road noise.

Here are two very successful Metalastik components; the Contrasonic spring shackle, evolved for the 3-litre Rover and the Metaxentric bush. The construction of the Contrasonic shackle is self-evident, also the canting of the twin units to resist lateral stresses. Fore-and-aft movement, as the leaf spring changes in length, is accommodated by the rubber in shear; weight by combined compression and shear.

A Metaxentric bush in the front eye of the spring and a Contrasonic shackle at the rear provides the most effective barrier yet devised against the transmission and amplification of noise.

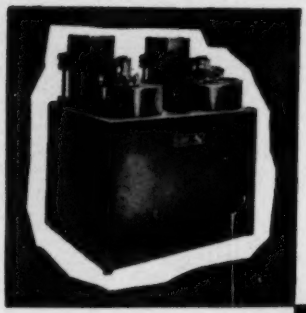
METAXENTRIC BUSHES

First fitted in spring eyes by the Standard Motor Company, Metaxentric bushes give much higher vertical deflections than concentric types. In fore-and-aft directions they are stiffer than in the vertical plane, the ratio being about 2·5 to 1.

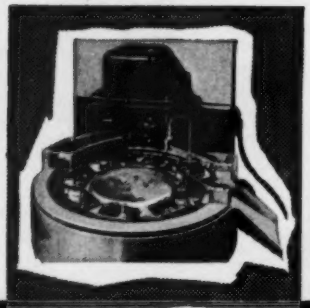
PATENTED

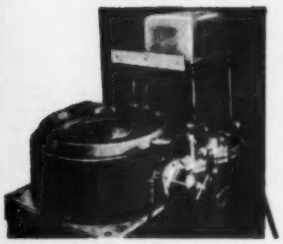
METALASTIK

METALASTIK LTD., LEICESTER

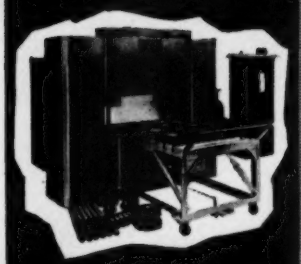


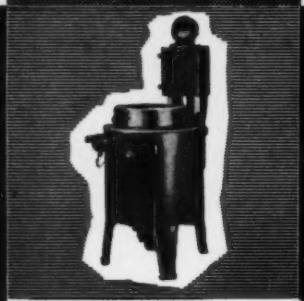
INDUCTION HEATING EQUIPMENT

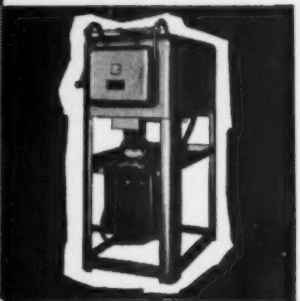


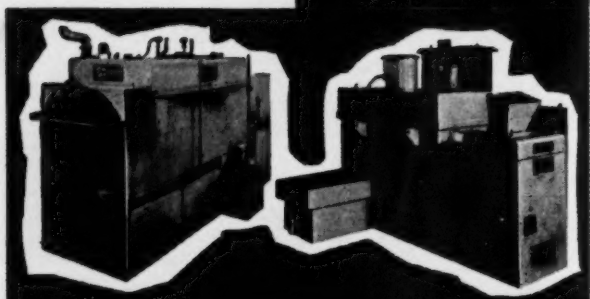


GENERAL PURPOSE FURNACES

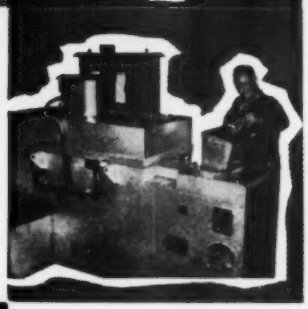


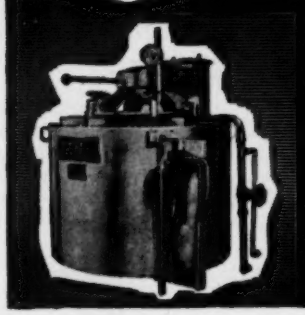


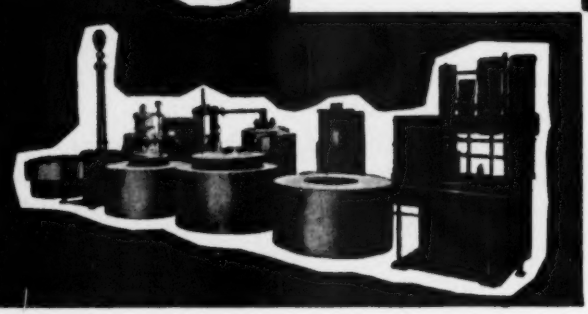




CONTINUOUS CARBO-NITRIDING FURNACES







GAS CARBURISING EQUIPMENT

Every heat-treatment requirement of modern industry is met by the very wide range of Wild-Barfield equipment.

Over 40 years' specialist experience of building electric furnaces to the highest standards of workmanship has placed Wild-Barfield in the unique position of being able to offer an unparalleled service both in research and manufacture.

ELECTRIC WILD BARFIELD FURNACES

FOR ALL HEAT-TREATMENT PURPOSES

Backed by 40 years' specialist experience

WILD-BARFIELD ELECTRIC FURNACES LIMITED

ELECFURN WORKS, OTTERSPOOL WAY, WATFORD-BY-PASS, WATFORD, HERTS. Phone: Watford 26091 (8 lines) Grams: Elecfurn, Watford

WB89

FROM STOCK

Have you tried Harris Tapping Lubricant? Available in 2-oz (8d), 7-lb (13/3d) and 28-lb (47/-) packs.

HARRIS

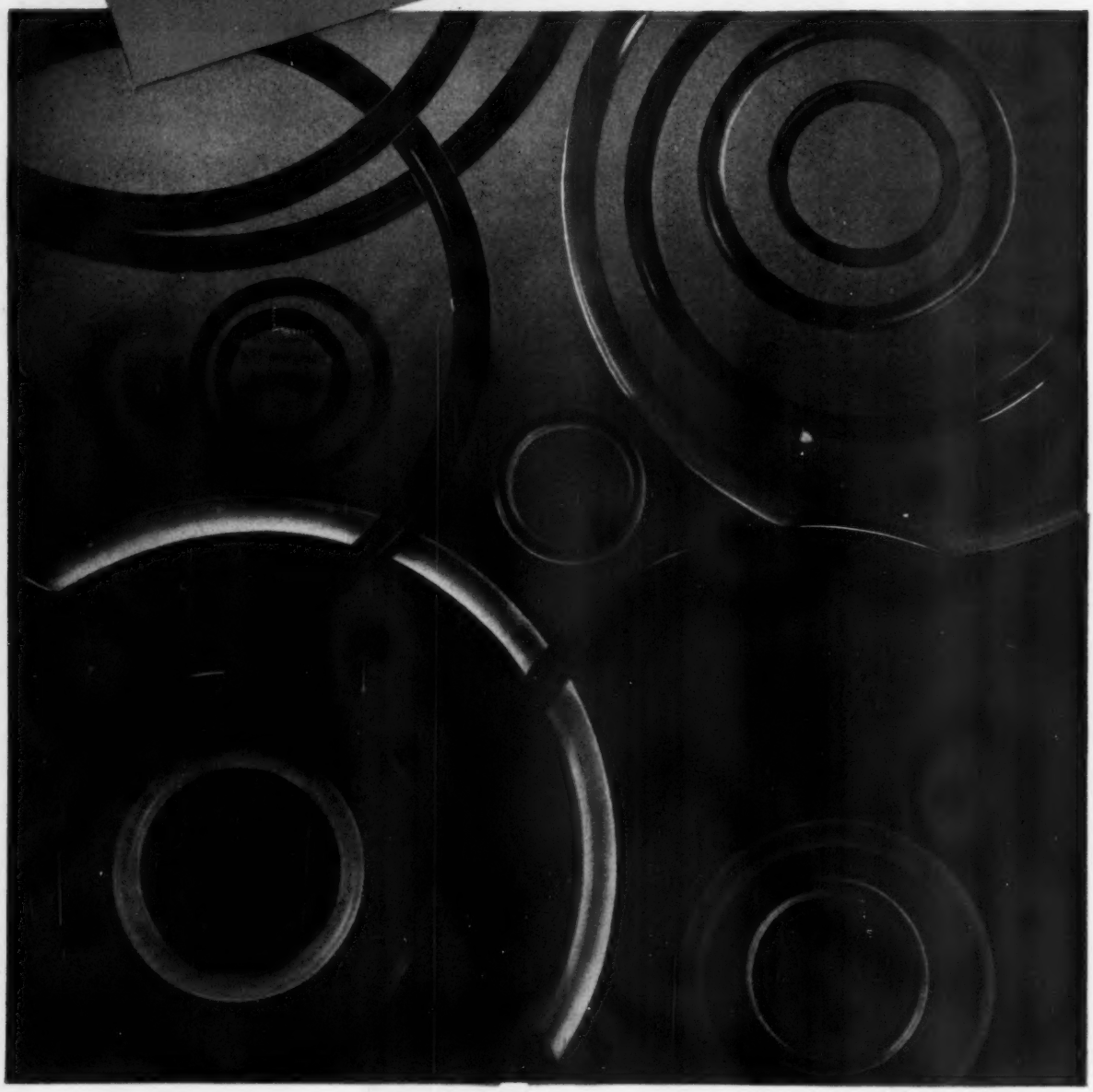
TAPS DIES AND GAUGES

JOHN HARRIS TOOLS LTD WARWICK

DOWTY

'O' RINGS

Natural, synthetic and silicone rubbers

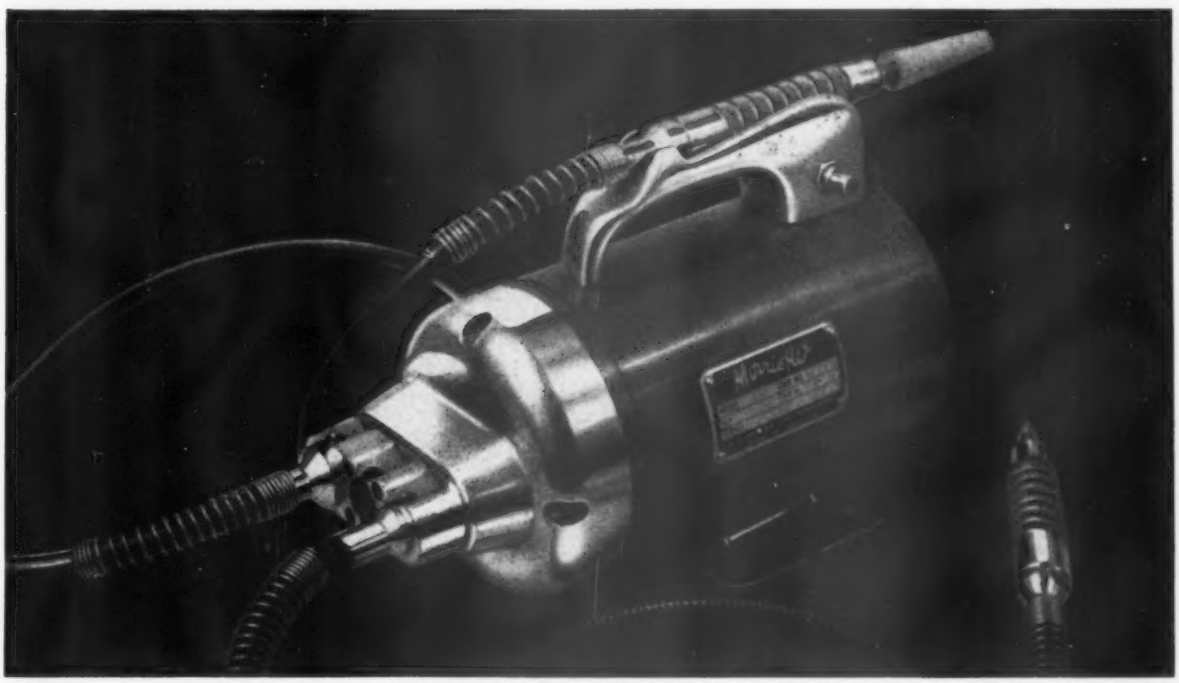


DOWTY SEALS LIMITED · ASHCHURCH · GLOS.

INTRODUCING THE *NEW*

Morrisflex 300

FLEXIBLE SHAFT MACHINE



QUICKER SPEED CHANGE
LIGHTER TO HANDLE
EASIER TO MANOEUVRE
FINER FINISH OBTAINED

The M300 is an entirely new machine specially designed for use in the tool room and in all cases where finish is of paramount importance. Optimum speeds are available for cutters in steel or carbide.

Details from

B. O. MORRIS LTD., MORRISFLEX WORKS, BRITON ROAD, COVENTRY. TELEPHONE: 53333 (P.B.X.)

Identical twins

This die-sinking machine is producing a metal punch for a car door outer panel, from a model made of Araldite epoxy resin. A stylus engages with the Araldite model, and its movements are repeated exactly in producing the metal punch. 4/5 weeks are required for the production of this punch, and the Araldite model retains its dimensional stability, in contrast with the distortion and fragility associated with the use of wood and plaster models. The Araldite unit is tough, durable and does not deteriorate in storage. Further information on numerous applications of Araldite in tool making is contained in a recent publication "Araldite for Tooling" manual B.T., which will be sent gladly on request.

Araldite epoxy resins are used

for producing patterns, models, jigs and tools.
for casting high grade electrical insulation.
for impregnating, potting and sealing electrical windings and components.
for producing glass fibre laminates.
as fillers for sheet metal work.
as protective coatings for metal, wood and ceramic surfaces.
for bonding metals, ceramics, etc.

Araldite

epoxy resins

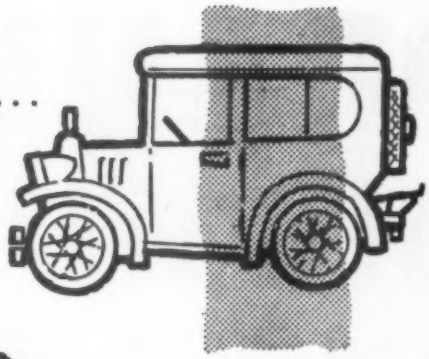
Araldite is a registered trade name

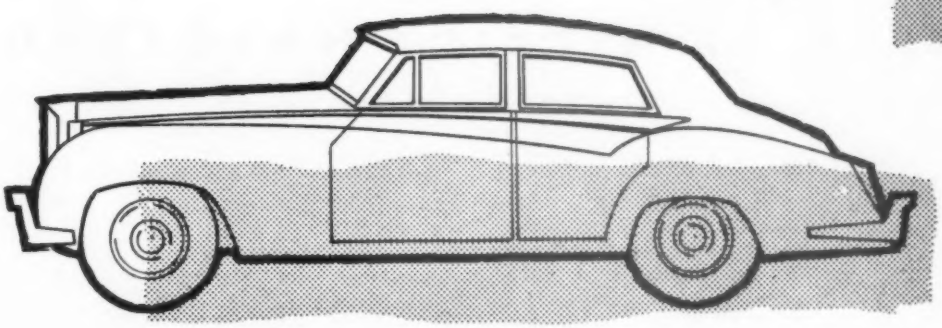
CIBA (A.R.L.) LIMITED,

Duxford, Cambridge. Telephone: Sawston 2121

AP 462

THERE ARE CARS . . .





AND CARS

AND THERE IS

CHROMIUM PLATE

AND CHROMIUM PLATE

Efco-Udylite

BRIGHT NICKEL PROCESSES

PROVIDE THE PERFECT UNDERCOAT FOR CHROMIUM

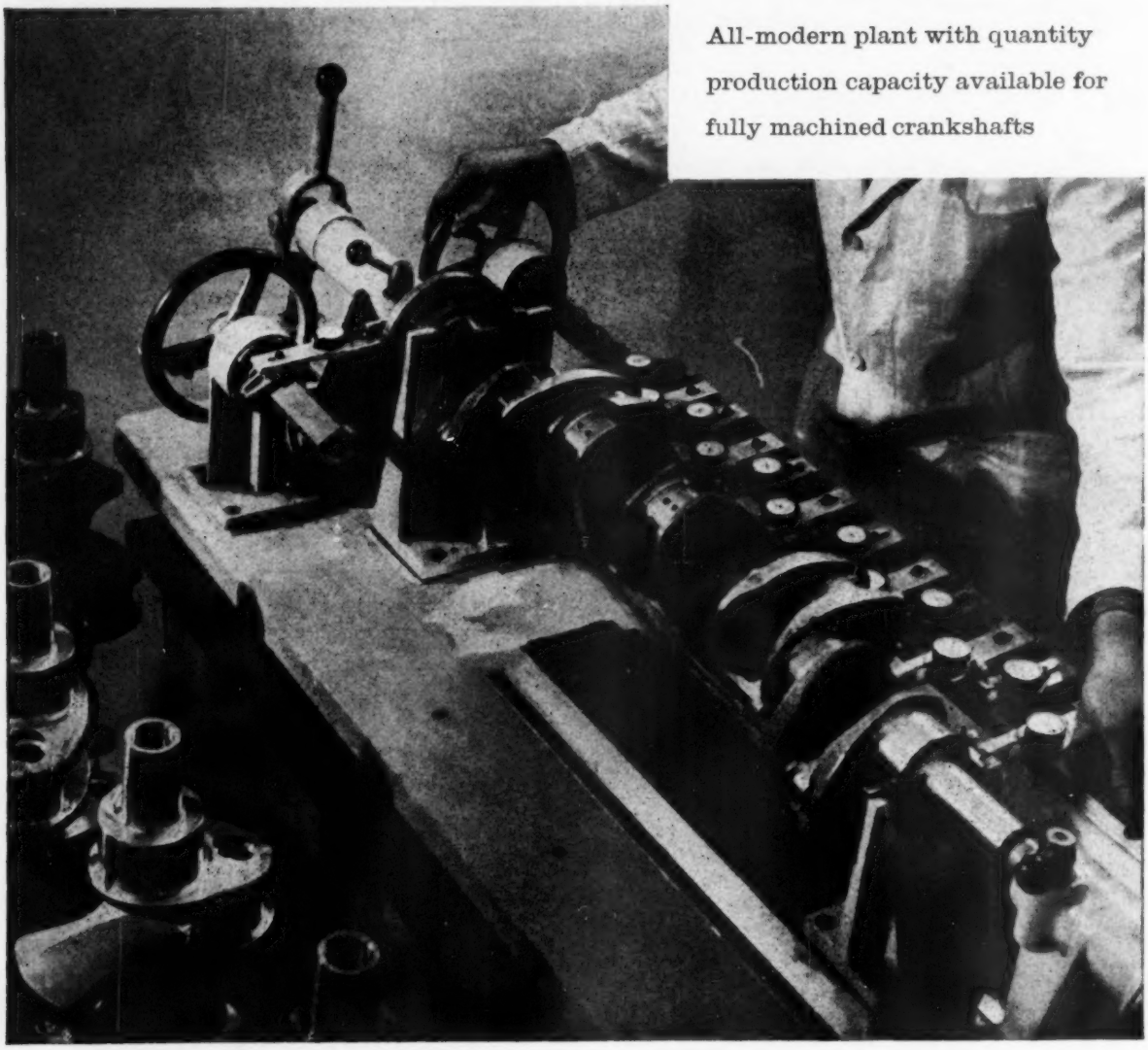
There is no finish for the bright parts of a motor car to equal good chromium plate for brilliance, appearance, ease of maintenance and low initial cost.
The world's best cars are fitted with many parts plated on EFCO-UDYLITE automatic plating machines by EFCO-UDYLITE plating processes.
Pre-eminent in their field, EFCO-UDYLITE design and research continually advance the standards of plating quality.

EFCO **ELECTRO-CHEMICAL ENGINEERING CO. LTD.**
SHEERWATER, WOKING, SURREY. Telephone WOKING 5222-7

RRP 2813

CRANKSHAFTS

INDUCTION OR NITRIDE HARDENED



All-modern plant with quantity production capacity available for fully machined crankshafts

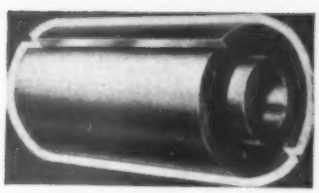
A member of the Guest, Keen & Nettlefolds Group of Companies

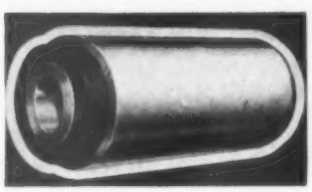
BRD COMPANY LTD., PRECISION & GENERAL ENGINEERS

ALDRIDGE, STAFFS · TELEPHONE: WALSALL 6551/9

NOW *HERE'S* A BEARING . . .

. . . which is earning quite an enviable reputation. Increasing numbers of satisfied users provide confirmation of our claim that the application of the Clayflex Principle to flexible bearing manufacture has resulted in the production of a range of units of advanced design and increased capacity. The Clayflex Principle is simple of description—it is the bringing together in one bearing of two well-tried techniques, the pressure bond and the chemical bond, and the retention, in the process, of the known advantages of both. Proof of these claims is equally simple—we will gladly co-operate with technical advice and test samples. Torsional spring applications are catered for with the B.S. type bearing—details upon application.





HOWARD CLAYTON-WRIGHT LIMITED

WELLESBOURNE · WARWICKSHIRE · ENGLAND

Telephone: Wellesbourne 316/7/8 · Telegrams 'Clatonrite' Wellesbourne

A CLATONRITE PRODUCTION

DU PONT neoprene
PARTS IN THE ROVER 3 LITRE

Rover's famous 3 litre is an outstanding example of the way Du Pont neoprene also plays a part in Britain's go-ahead motor car industry. Du Pont neoprene applications include: steering hose, brake diaphragms, wire coverings, lamp gaskets, suspension dust boots, protective coatings and adhesives. Automobile engineers are doing many interesting things with neoprene, Du Pont's versatile synthetic rubber. They specify neoprene because it offers *balanced* resistance to all the causes of deterioration—including petrol and oil, ozone, sunlight heat and weather. And because it can be compounded and formed in many ways, to perform many specialized functions supremely well. Du Pont neoprene can be utilized in more ways than you may have realized. For a copy of the Du Pont Elastomers Notebook, featuring new developments with Du Pont neoprene, send us the coupon below.

DISTRIBUTORS Du Pont Company (United Kingdom) Ltd, 76 Jermyn Street, London, S.W.1

DU PONT REG. U.S. PAT. OFF. ESTABLISHED 1802 **neoprene**

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Du Pont Company (United Kingdom) Ltd.
Room 523, 76 Jermyn Street,
London, S.W.1, England. *Please send me a copy of the Du Pont Elastomers Notebook. I am particularly interested in*

_____

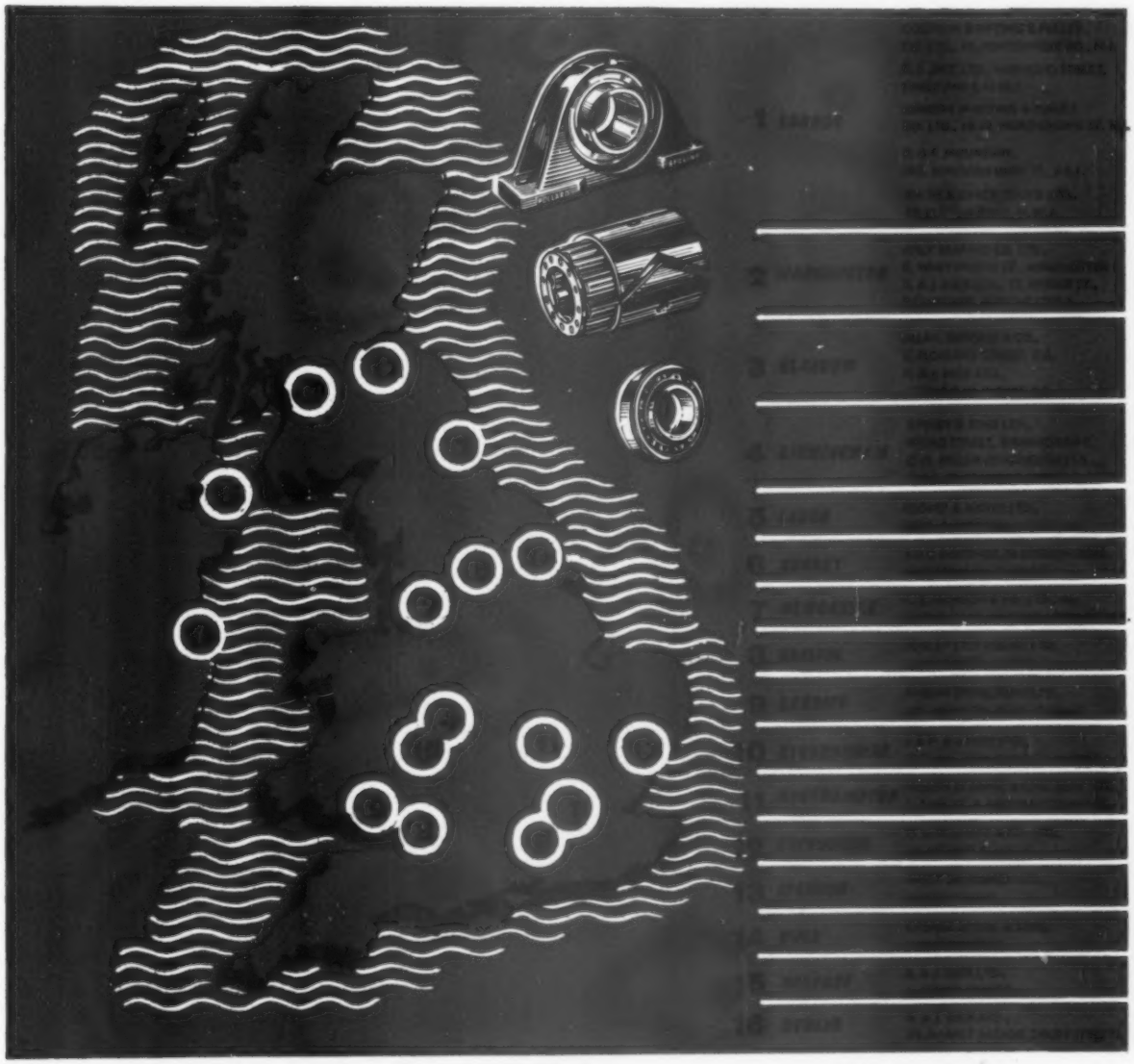
NAME _____

POSITION _____ COMPANY _____

ADDRESS _____

CITY _____ COUNTRY _____

THE FOLLOWING ARE APPROVED STOCKISTS OF
POLLARD BEARINGS



POLLARD BEARINGS LIMITED

FERRYBRIDGE · KNOTTINGLEY · YORKSHIRE

Telephone: Knottingley 2323 (5 lines)

Telex: 55166 · Telegrams: "Ballbearing Ferrybridge"

LONDON OFFICE: 44 HERTFORD STREET, W.1
Telephone: Legation 3888 · Telex 23547

NORTHAMPTON WORKS: COUNTESS ROAD
Telephone: Northampton 3766 · Telex 31624

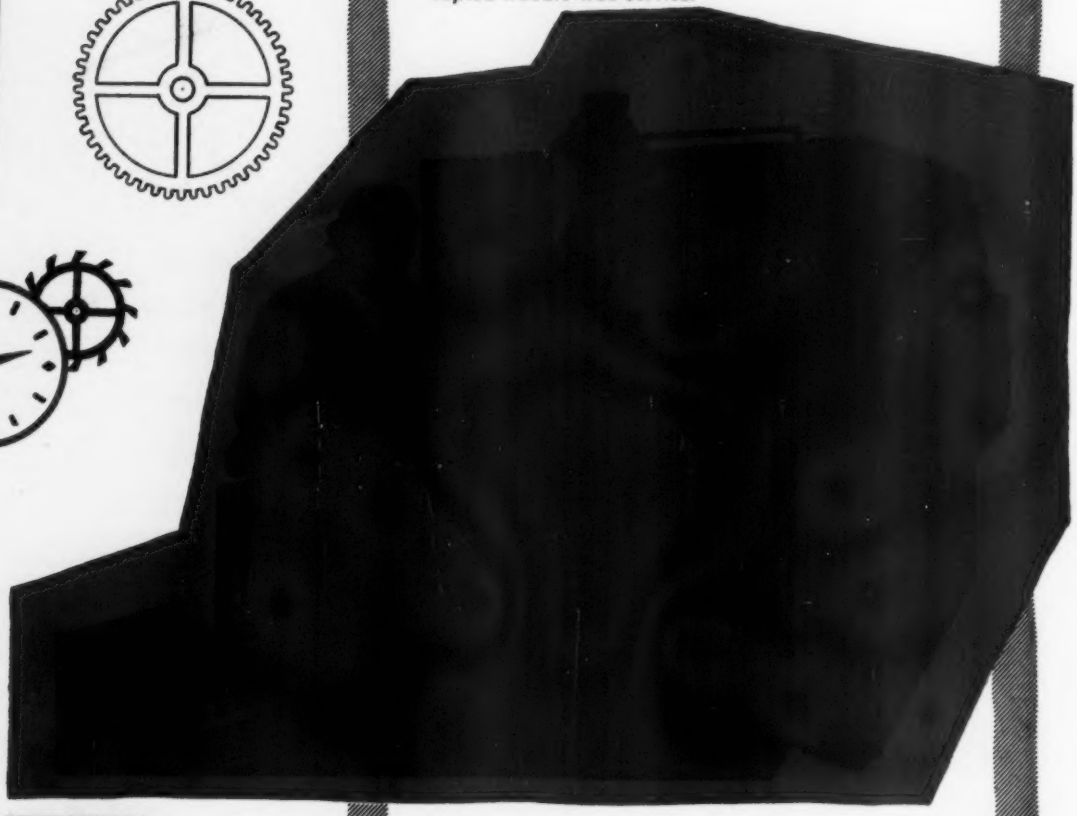
PARIS OFFICE: POLLARD-ROULEMENTS, 98 RUE TRUFFAUT, PARIS 17e. · Telephone: MARcadet 09-10.

POLLARD PB BEARINGS

MAKING TIME

Here at the Wishaw factory of Smiths Clocks & Watches, a division of S. Smith & Sons (England) Ltd., they **make** time—or at least time pieces. Manufacturing a large proportion of Smiths clockwork alarms, industrial timers and domestic ringers, the factory produces some fifteen to twenty thousand units daily, over a quarter of which are exported. Four brazed components are fitted to each of these clocks and are brazed in a 20 kW Birlec mesh belt conveyor furnace. On the average the furnace works 18 hours a day for five days a week.

** The cost of a furnace is not necessarily its purchase price. Any interruption in production may cause serious losses in output, particularly in modern factories where stocks are deliberately streamlined. The purchaser of a Birlec furnace can be confident that the equipment will not only meet his specification but will give uninterrupted trouble-free service.*



EXTRA SPECIFICATION FURNACES*

BIRLEC

SM/B5021

BIRLEC LIMITED

An A.E.I. Company

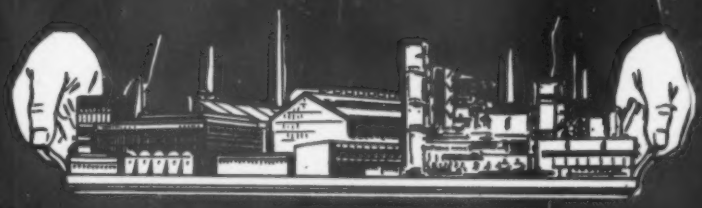
ERDINGTON • BIRMINGHAM 24 • Tel. EASt 1544

LONDON · SHEFFIELD · GLASGOW
NEWCASTLE ON TYNE · JOHANNESBURG

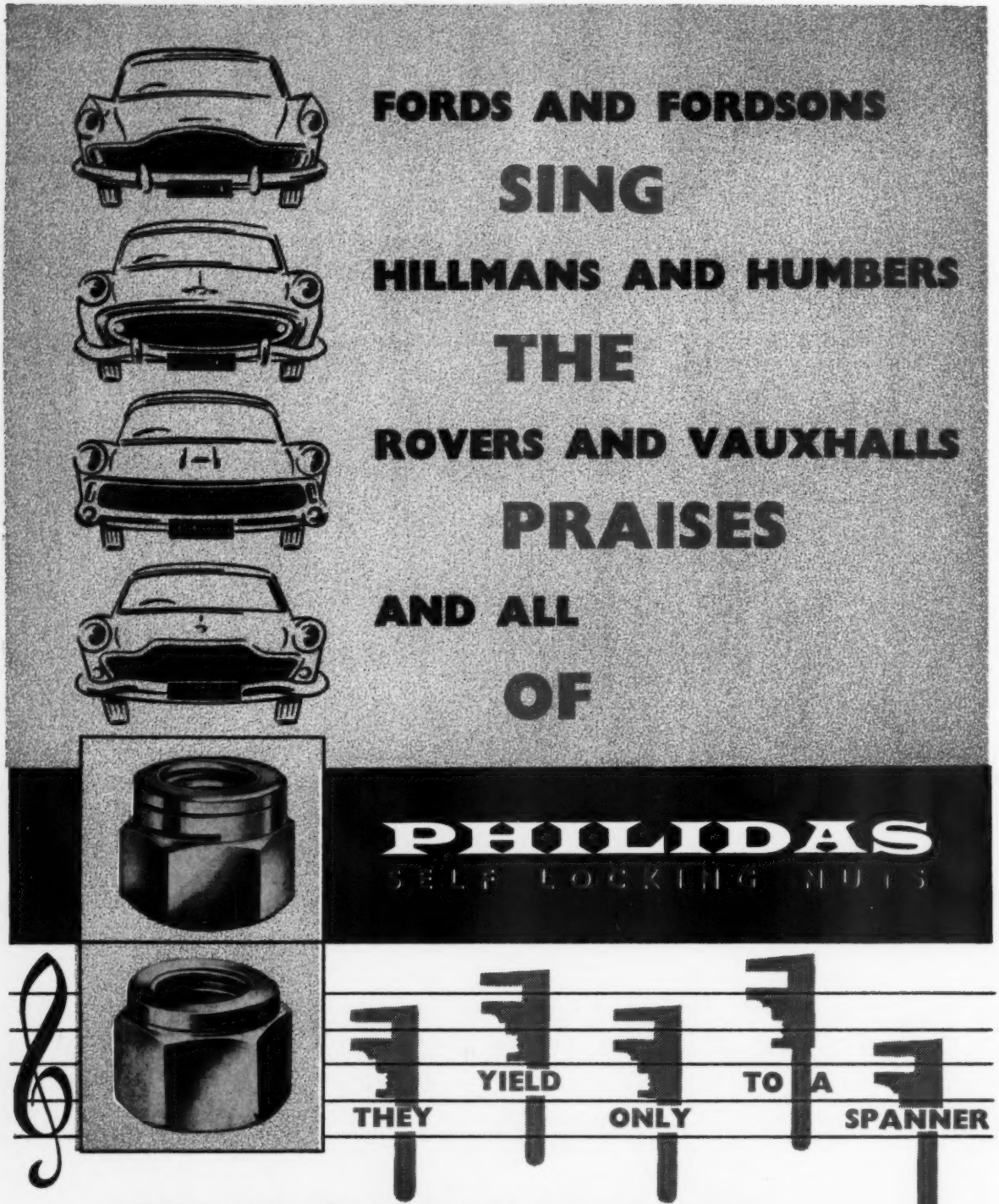
MEADOWFELT
REGISTERED

SERVES INDUSTRY

WELL...



MEADOWFELT
REGISTERED
DOES SO MANY JOBS SO WELL



MOST TYPES AND SIZES AVAILABLE FROM STOCK

SEND FOR OUR NEW CATALOGUE

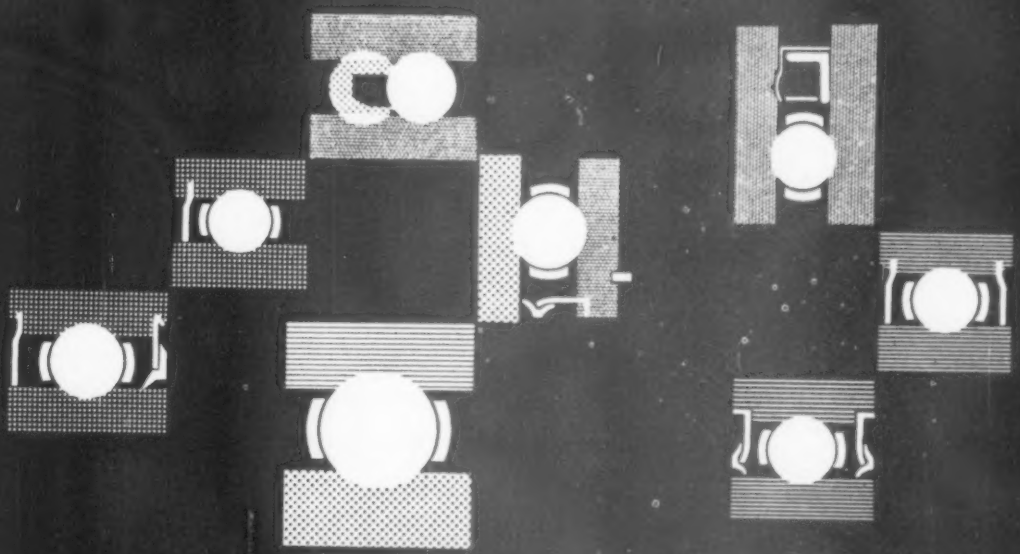
PHILIDAS DIVISION — WHITEHOUSE INDUSTRIES LTD

FERRYBRIDGE, KNOTTINGLEY, YORKS

Tel: Knottingley 2323 (5 lines). Telex 55166

London Office & Stockroom: 44 Hertford Street, W.1. Tel: LEGation 3888 Telex 23549

Northampton Office & Stockroom: Countess Road, Northampton
Tel: 3766. Telex 31624



R M RIGID BALL JOURNALS

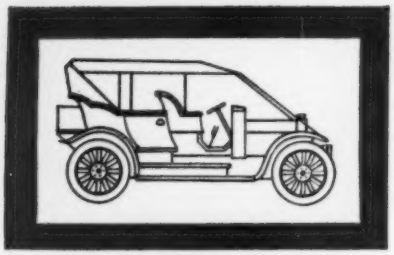
one of the basic types from a range of ball and roller bearings designed to meet every speed, load and application.

- Tremendous adaptability for speeds, loads or temperatures.
- Wide range of load duties merely by varying the internal clearance.
- Big demand and standardisation lead to low cost.
- Ability to compensate for slight errors in alignment.
- Variations available for particular applications — fitted with one or two shields or seals; notched rings for increased capacity; snap rings for location purposes; a variety of special materials for high speeds.

R|M RIGID BALL JOURNALS BRING YOU THESE BENEFITS

Have you a copy of our Publication 271? Full technical details of Rigid Ball Journals will be found on pages 96 and 97.

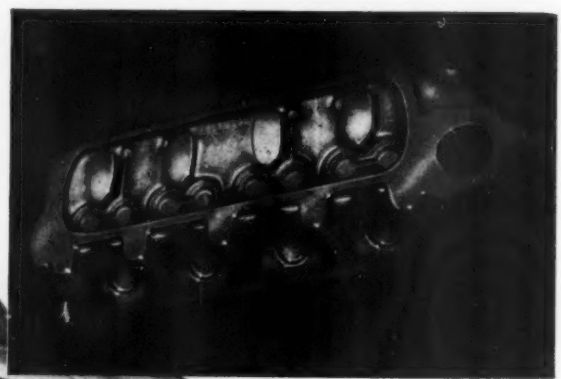
RANSOME & MARLES BEARING COMPANY LIMITED
NEWARK-ON-TRENT · TELEPHONE 456 · TELEX 37-626
BRANCHES · OFFICES AND AGENCIES THROUGHOUT THE WORLD



Sterling achievements span the history of an era

. . . and help to make that era memorable.
The continuing success of Sterling Metals is due to their ability to supply castings of the highest quality in the desired quantities at the right time.
Today as in the past, Sterling Metals offer the greatest technical experience augmented by quality control of production which is second to none.
Sterling Metals are the acknowledged experts in casting aluminium and magnesium alloys by sand, die and precision mould processes, and in making engine blocks and cylinder heads in high duty iron.

Sterling Metals are at your service



Cast iron cylinder head
for Austin A35 car.
By courtesy of Austin Motor Co Ltd.

STERMET
REG. TRADE MARK

STERLING METALS LTD

NUNEATON · Nuneaton 4221

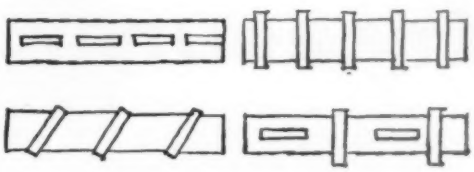
Lighting-2

The general principles of factory lighting have been dealt with in the previous data sheet (No. 6). This one considers briefly certain factors—not always fully appreciated — that influence the lighting for some particular factory applications. The next data sheet will carry the subject further.

Work benches

The most universal application of lighting is to bench work, for there is no branch of manufacturing that does not have its work benches which, of necessity, are used for a great variety of occupations. No single lighting method is suitable for all cases.

The introduction of fluorescent lighting has gone a long way to solving one of the main problems here; for while the high degree of brightness of filament lamps tends to preclude their use for individual lighting owing to the glare, the fluorescent tube with its greater expanse of light source has made localised lighting with a low mounting height more practicable. Moreover, the length of the fluorescent tube puts into the hands of the designer a means of controlling shadows which, together with glare, probably represent the most prolific causes of errors and eye-strain.



With narrow individual benches (not more than 4 ft. wide), there are four basic methods of localised lighting: longitudinal, transverse, diagonal or a combination of longitudinal and transverse. With wider benches it is not advisable to use fittings directly over benches, and fittings should be behind the workers at each edge of the bench. Where particularly high illumination is required, fluorescent fittings may be mounted as local lights—low enough for the skirt of the reflector to conceal the lamps from the eye of the operator.

It is good practice to use reflectors which allow a reasonable amount of light to spill upwards, giving a certain amount of general lighting.

High-bay shops

Probably the most difficult of all factory lighting problems is that of high-bay lighting. In lofty, long and sometimes necessarily dirty shops such as those which house really large machine tools and overhead cranes, which do their worst to defy the efforts of the illuminating engineer, it requires great ingenuity, coupled frequently with high lamp wattage, to provide the workman with enough light to allow him to do his job efficiently. From the planer operator to the slinger, the workman, though he may not know it, is dependent on good lighting if he is to avoid an over-cut or a serious crane mishap.

The major problems associated with the lighting of high and relatively narrow shops, such as heavy machine shops and foundries, are :—

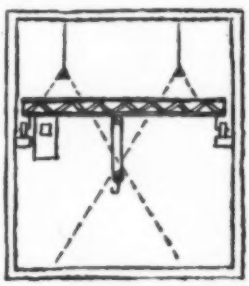
(a) Poor light utilisation caused by excessive light absorption by the large and often dark wall area.

(b) Preponderance of light flux downwards and poor cross lighting causing poor illumination on vertical surfaces, and heavy shadows.

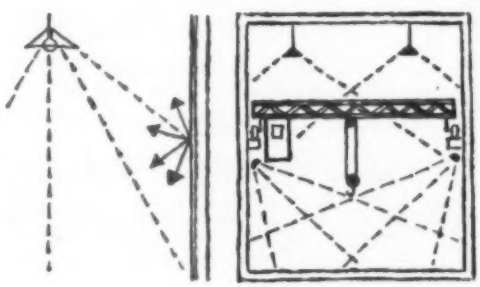
(c) Possibility of heavy light absorption in the atmosphere.

(d) Difficulty of access to high fittings for maintenance.

In high-bay workshops there is a tendency to use concentrating fittings so that the maximum proportion of the light output reaches the working area without spread to the walls, but the saving in wall absorption is obtained only by accepting a depressing environment, poor cross lighting and heavy shadows.



In many cases it is good practice to accept the inevitable reduction in light utilisation by wall absorption and to reduce this by applying light colours to interior surfaces where possible throughout. This approach results in more cheerful conditions and provides equally good illumination values and better cross lighting. Even better is to add angled lighting from the sides below crane level.



In the conditions obtaining in this type of shop, rapid deterioration in light source intensity due to dust must be expected. Facilities should always be provided for easy access to fittings for cleaning and maintenance.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone : TEMple Bar 9434.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available—"Lighting in Industry" is an example.

E.D.A. also have available on free loan in the United Kingdom a series of films on the industrial uses of electricity, including one on industrial lighting. Ask for a catalogue.

7911

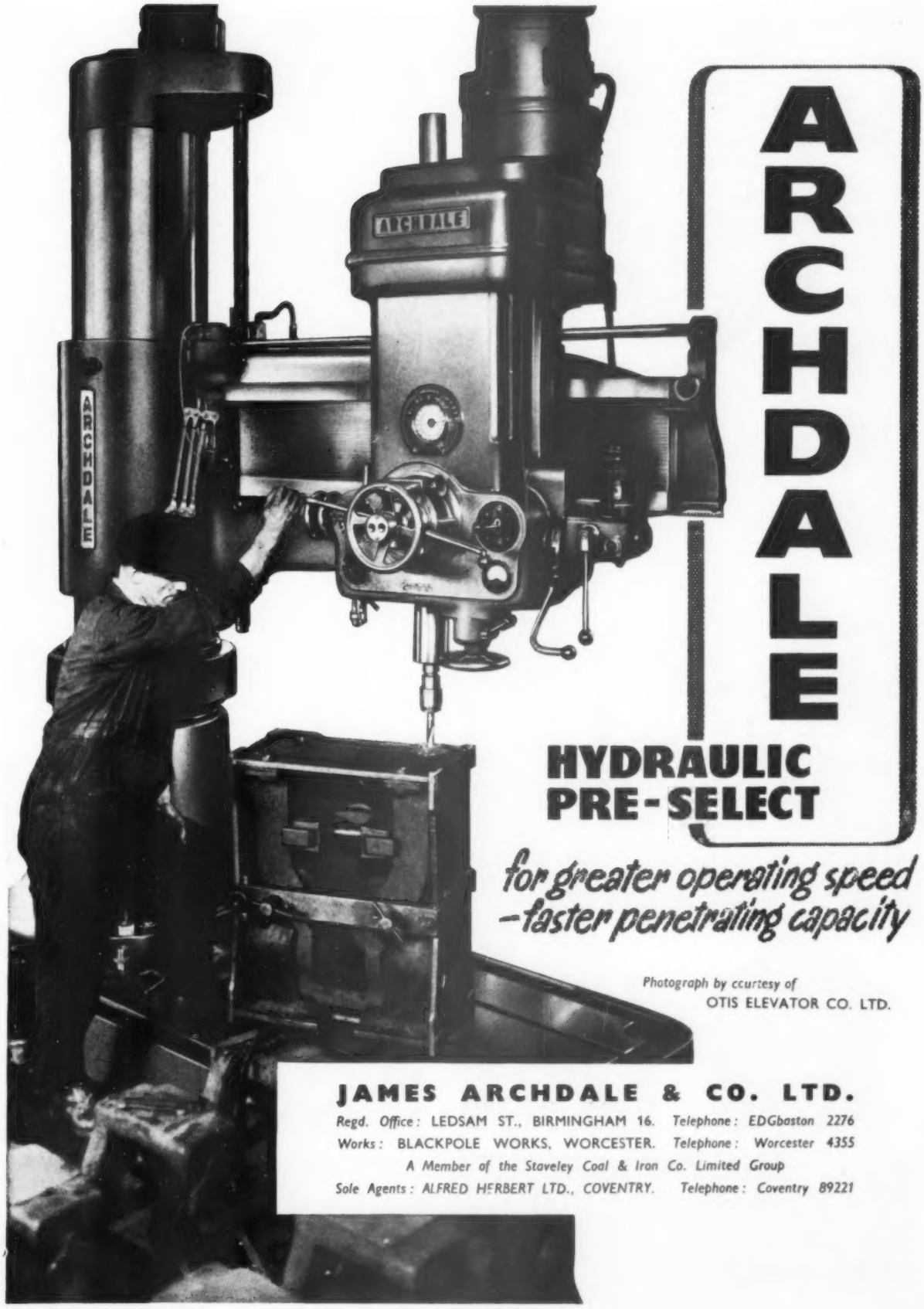
CUT HERE

Hidden treasures

Deep in the heart of China, on the walls of the Mok Ko caves in the Wu Sha Mountains of the Tun Huang District of Kansu, are the wall paintings, sculptures, and carvings of a thousand years—a veritable treasure of Chinese Art. And deep in the heart of the world's finest car engines another treasure is hidden . . . silent . . . enduring . . . vital . . . a Renold Timing Chain. It's a gem of a chain—smooth running and flexible, capable of innumerable driving arrangements and outliving the engine itself.

RENOLD **TIMING CHAINS**
stand the test of time

RENOLD **RENOLD CHAINS LIMITED • MANCHESTER**



ARCHDALE

HYDRAULIC PRE-SELECT

for greater operating speed –faster penetrating capacity

Photograph by courtesy of
OTIS ELEVATOR CO. LTD.

JAMES ARCHDALE & CO. LTD.

Regd. Office: LEDSAM ST., BIRMINGHAM 16. *Telephone:* EDGbaston 2276
Works: BLACKPOLE WORKS, WORCESTER. *Telephone:* Worcester 4355
A Member of the Staveley Coal & Iron Co. Limited Group
Sole Agents: ALFRED HERBERT LTD., COVENTRY. *Telephone:* Coventry 89221

GET BROOK
TO QUOTE
NEXT TIME!

LARGE
TOTALLY
ENCLOSED
FAN COOLED
MOTORS
up to 250
horsepower

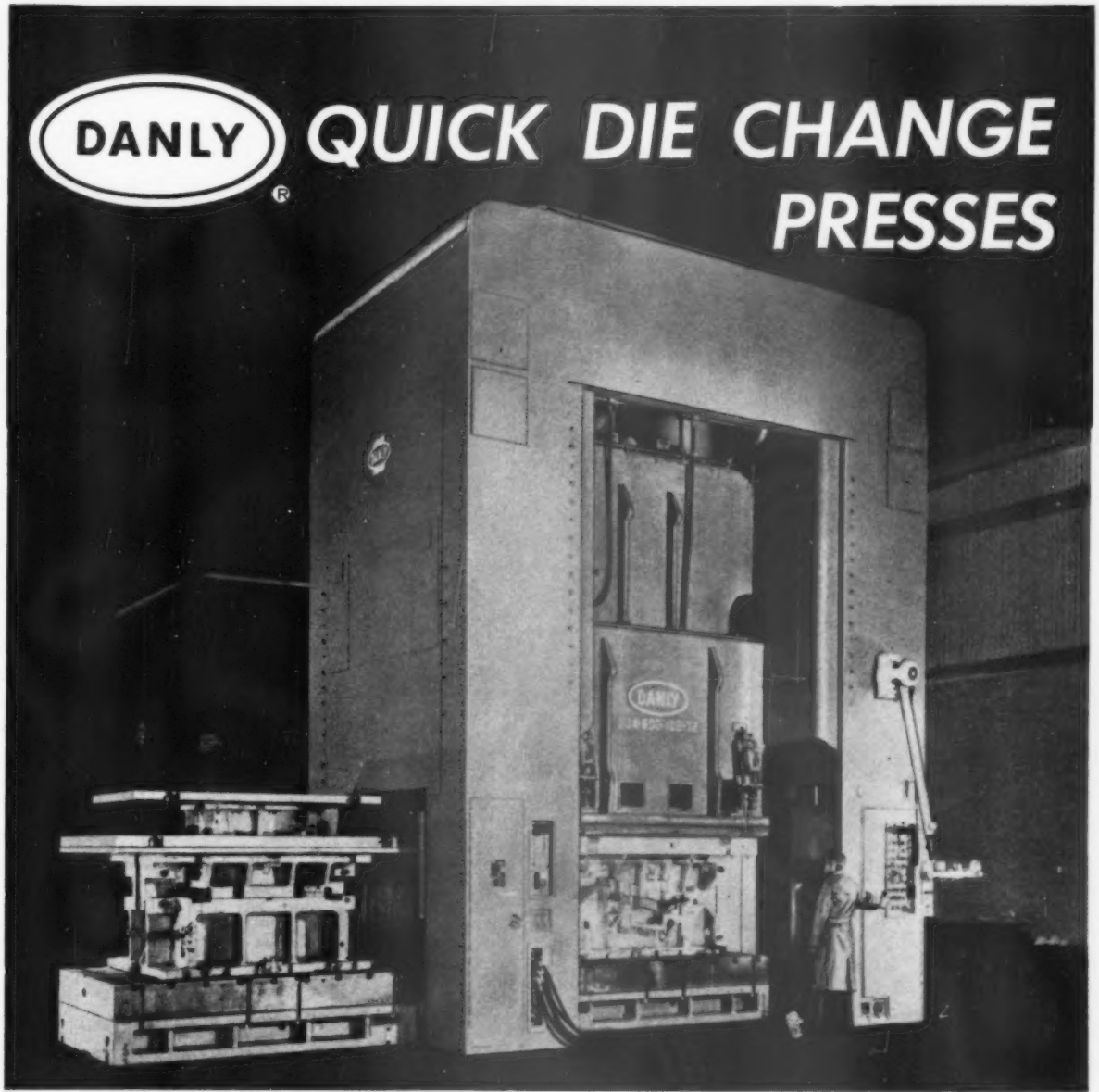
BROOK
MOTORS
Ltd

HUDDERSFIELD ENGLAND

59/8

DANLY®

QUICK DIE CHANGE PRESSES



Make die change a matter of minutes

Offer greater production from lesser number of presses.

All types: single, double, triple action.

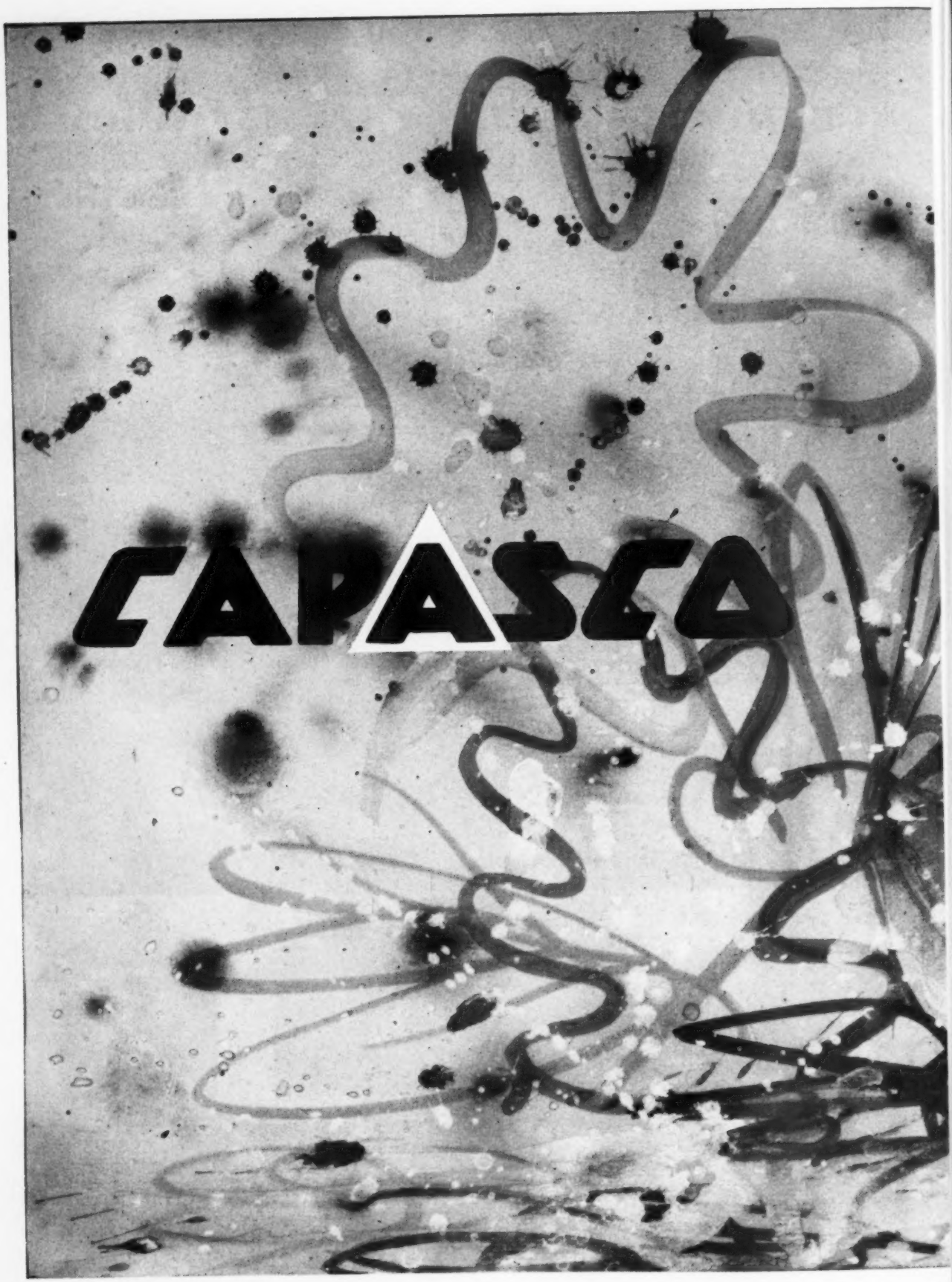
Any tonnage or size specified within transportation limits.

DANLY MACHINE SPECIALTIES, INC., Chicago 50, Illinois U.S.A.

SELLING AGENTS IN GREAT BRITAIN : GASTON E. MARBAIX LTD

DEVONSHIRE HOUSE · VICARAGE CRESCENT · LONDON—S. W. 11

Danly Presses are built in the United States and United Kingdom


CAPASCO

Capasco takes care of the braking

non-fade moulded linings & facings

THE CAPE ASBESTOS COMPANY LTD

114 & 116 Park Street, London W.1 GROsvenor 6022

There is no substitute for a C.A.V. Paper Filter

Where else can you find a filter of such high efficiency with adequate service life? The C.A.V. fuel oil filter removes from the fuel a high proportion of the minute abrasive particles which wear the finely fitting parts of fuel injection pumps and injectors, and which pass through many filters. But with high efficiency it is inevitable that the filter element will become choked in time—its life depends largely on the effective filtering surface area. In the C.A.V. filter, this is 560 sq. inches—several times more than most other types, ensuring the longest life commensurate with adequate filtration.

Great care is taken in testing and checking C.A.V. paper filter elements during manufacture. Substitutes are frequently faulty and are no safeguard to fuel injection equipment.

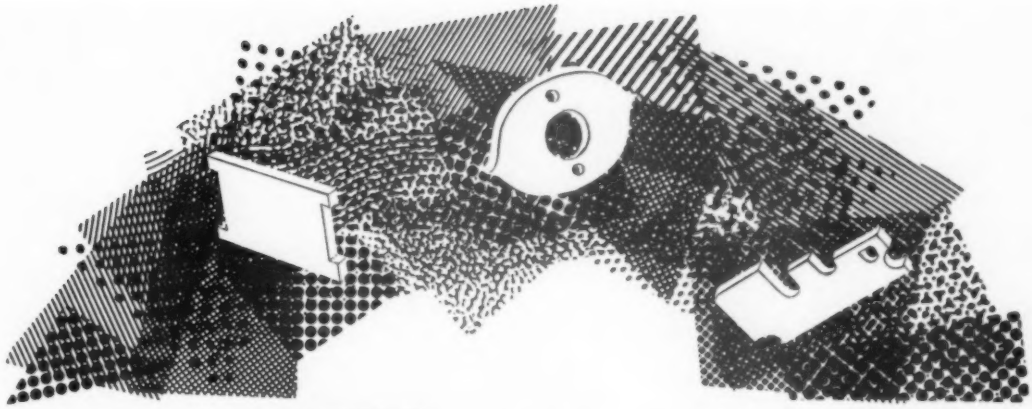
WHY TAKE RISKS? The C.A.V. element is low in price—insist on the genuine article

Manufacturers of

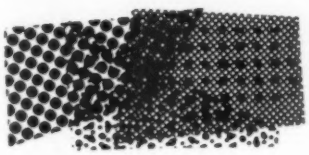
ELECTRICAL & FUEL INJECTION EQUIPMENT

C.A.V. LIMITED, ACTON, LONDON, W.3.

AP 948



Let BURY FELT solve your problem



You'll find Bury Felt everywhere—as washers, seals and gaskets, polishing bobs, anti-vibration bases and buffing rollers. These are only a few of its hundred and one uses. You will think of many more. For Bury Felt is what you make of it; it can be chiselled, punched, machined or die-cut to suit your needs and is available in many types and textures.

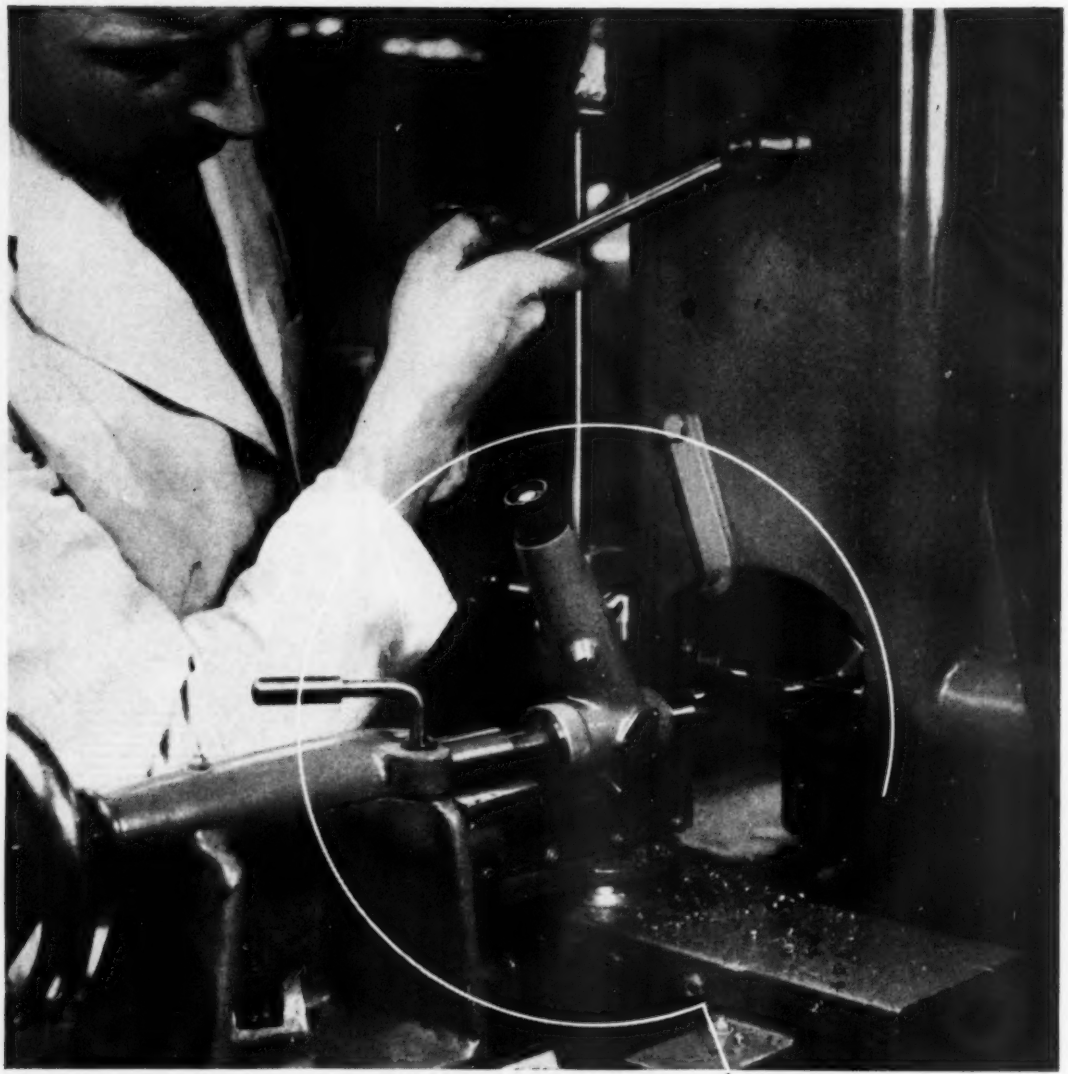
Versatile stuff—

Send your enquiries to
BURY FELT MANUFACTURING COMPANY LIMITED,
P.O. BOX 14, HUDCAR MILLS, BURY, LANCASHIRE
Phone: BURY 2262 (6 lines)
London Offices: 3 Snow Hill, EC1.
Phone: CENtral 4448

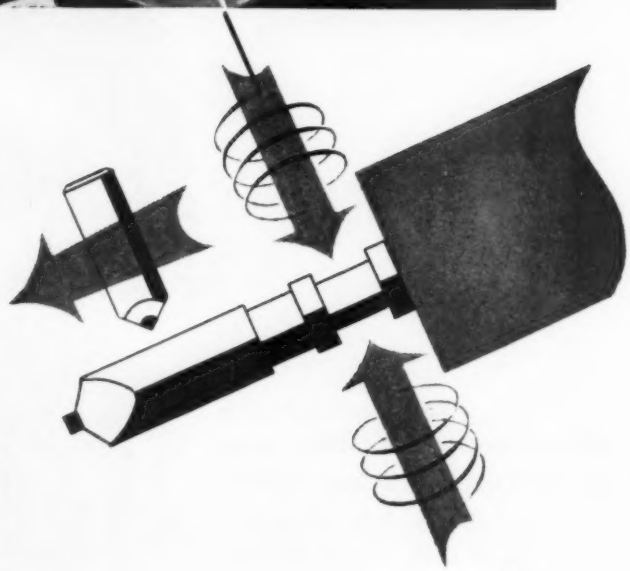
BURY FELT

64

Also manufacturers of
'FOAMBURY' Plastic Foam products



Our combined lathe and milling machine was designed especially for the production of Diatipt chisels for the Diaform wheel forming attachment Optical centring is provided to ensure consistent accuracy



L.M. VAN MOPPES & SONS (DIAMOND TOOLS) LTD
BASINGSTOKE · HAMPSHIRE · ENGLAND

TELEPHONE BASINGSTOKE 1240 · TELEGRAMS DIATIPT, BASINGSTOKE

J. W. 1

FOUNDRY PLANT & SUPPLIES
CONTRACTORS' PLANT—SALE & HIRE
CEMENT
Fit
WARDS
into
RAILS AND SIDINGS
SHIPBREAKING
your
industrial
planning
STRUCTURAL STEELWORK
MACHINERY AND MACHINE TOOLS
TRACTORS
SCRAP IRON AND STEEL
ROAD MATERIALS
GO
INDUSTRIAL PLANT
THOS. W. WARD LTD
ALBION WORKS · SHEFFIELD
London Office · Brettenham House · Lancaster Place · Strand W.C.2
FOOD PREPARING
MACHINERY
DISMANTLING
FACTORY PLANNING & INSTALLATION

Produce more, earn more with ARO-BROOMWADE pneumatic tools

*** LIGHT * POWERFUL * SPEEDY**

*** RELIABLE * LOW COST**

Wherever ARO-BROOMWADE tools are used, costs per unit of production fall, profits per unit rise. Why not find out NOW how these tools can save you money. Demonstration on request.

Lever Model

Pistol Model

LIGHT, SPEEDY DRILLS

A real asset in Aircraft, Electrical, Television, Radio and other light industries. Both models weigh less than 1½ lb. Best power/weight and power/air ratios. Locked-in motor. Capacity $\frac{3}{16}$"—$\frac{1}{4}$".

SILENT, REVERSIBLE SCREWDRIVER & NUTRUNNER

A high-speed tool (1800 R.P.M.), weighing approximately 1½ lb. Readily converted to either function. Instant push-button reverse action. Adjustable clutch can be pre-set to correct torque, the clutch jaws automatically disengaging at the required tension.

Write or phone for Publication No. 439 T.E.

"BROOMWADE"

AIR COMPRESSORS & PNEUMATIC TOOLS

Your Best Investment

Broom & Wade Ltd., P.O. Box No. 7, High Wycombe, England. Telephone: High Wycombe 1630 (10 lines). Telegrams: Broom, High Wycombe. (Telex)

688SAS

It's a more profitable move . . .

with DURALUMIN
REGD. TRADE MARK

and 'MG 5' *bodywork*
REGD. TRADE MARK

1

2

3

4

Bigger loads—lower running costs
Bigger profits!

1 'Duralumin' has been used for the entire cab, bodywork, sub-frame and flooring of this 25 cu yd capacity end-tipping vehicle. Specially built for John Hudson Ltd. for transporting coal in bulk, its durable bodywork must withstand arduous duties.
(*Courtesy Duramin Engineering Co Ltd*)

2 In this 'Duple' motor coach 'MG5' alloy is used in the form of durable, easily cleaned chequer-plate for flooring, steps and wheel arches. It resists the abrasive wear of scuffling feet, kicks and bumps, and a quick wash over keeps it bright and clean. (*Courtesy Duple Motor Bodies Ltd*)

3 Strong lightweight 'Duralumin' has been extensively used in the bodywork as well as for the entire flooring of this modern delivery van, made for Bentalls Ltd. of Kingston-upon-Thames. Unloaded weight is considerably reduced and as a result running costs will be lower.
(*Courtesy Duramin Engineering Co Ltd*)

4 This Leyland Octopus eight-wheeler is fitted with heavy-duty 'Duraplank' flooring manufactured from 'Duralumin'. This enables it to withstand abrasive, heavy wear and accept loads where weight is concentrated in small areas of the flooring.
(*Courtesy Duramin Engineering Co Ltd*)

Our Technical Sales Section will gladly help you to take full advantage of 'Duralumin', 'MG5' or any other James Booth light alloys, for modern motor vehicle bodywork

James Booth

James Booth & Company Limited, Argyle St. Works, Birmingham 7

Extrusions, large forgings, plate, sheet, strip, tubes and wire in brass and copper, as well as light alloys

DELTA GROUP
LONDON & BIRMINGHAM
TGA 387 155

When one stops to think about it there are not many forms of transport that do not include Hardy Spicer Propeller Shafts and Universal Joints. In fact they tend to be taken very much for granted when people get round to talking about dependability, design, and performance. Take a look at the range of commercial vehicles depending on Hardy Spicer Propeller Shafts and Universal Joints and you will see what we mean.

HARDY SPICER

PROPELLER SHAFTS

HARDY SPICER LIMITED

CHESTER ROAD · ERDINGTON · BIRMINGHAM 24 · ERDINGTON 2191 (18 LINES)

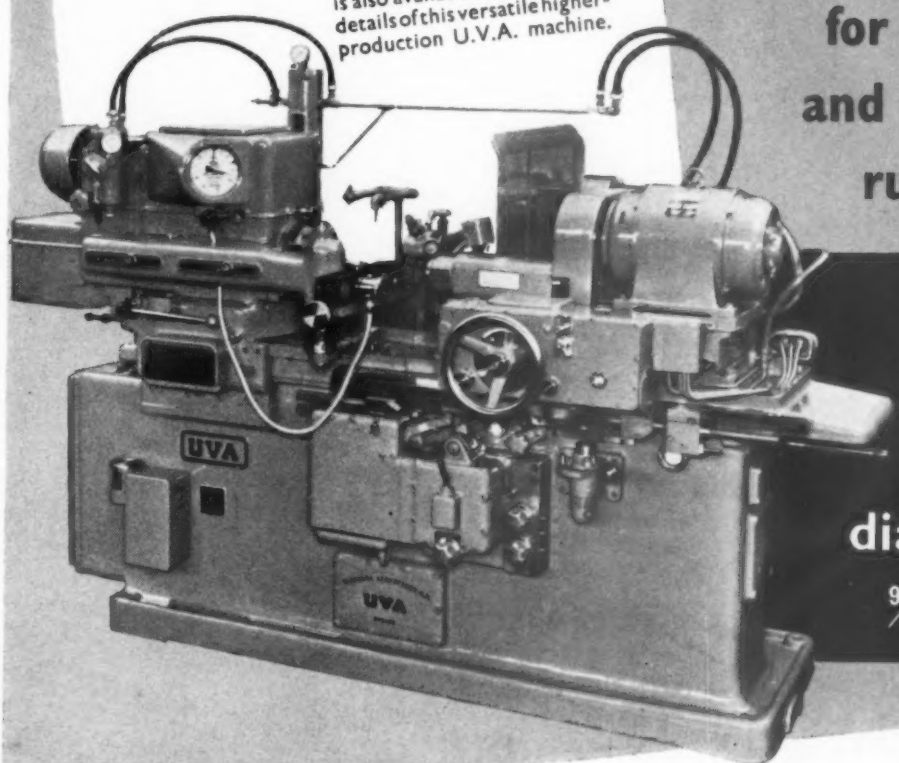
Automotive Division of BIRFIELD INDUSTRIES LIMITED, Stratford House, W.1

product of the Birfield Group

UVA

Automatic Internal Grinding Machines for long and short runs

U.V.A. Internal Grinding Machines have been designed in close co-operation with customers in the ball bearing and automobile industries and are capable of high rates of production, extreme accuracy and superior surface finish. The Type UMH 195 illustrated, operates on a completely automatic operating cycle which is divided into a coarse and fine grinding operation between which the wheel is trued. Rapid, hydraulic chucking ensures quick loading and unloading and automatic sizing by gauges is standard. Automatic sizing by measuring finger with the Deltameter (as illustrated) is also available. Write for full details of this versatile higher-production U.V.A. machine.



with range of work diameters 9/16" to 8"

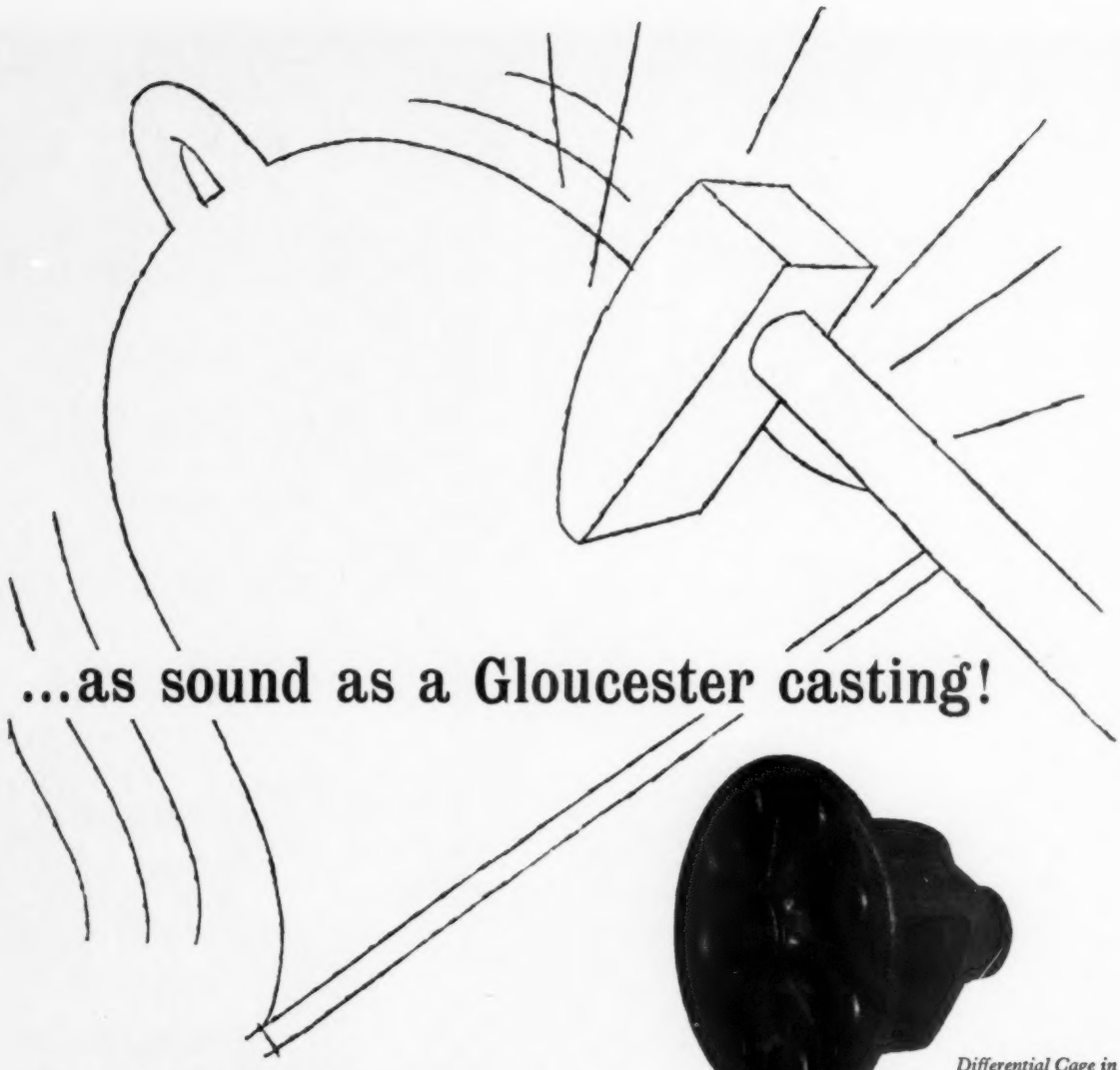
SPECIFICATION Type UHM-195.

Range of work diameters....$\frac{9}{16}$" – 8"
Length up to.....8"
Max. swing with splash guard..14$\frac{9}{16}$"
Swing without splash guard.....17"
Max. travel of work table.....23$\frac{5}{8}$"
Speed of table travel....0-33 ft./min.
Spindle speeds.....180–835 r.p.m.
Max. angle of headstock.....20°
Motor for grinding wheel 7$\frac{1}{2}$ – 13$\frac{1}{2}$ h.p.

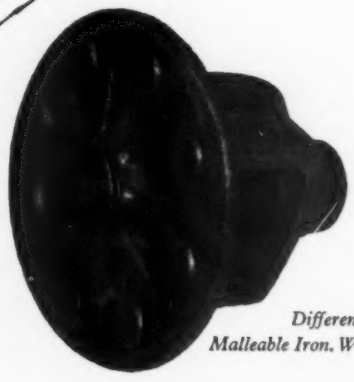
Sales and Service for the British Isles

DRUMMOND-ASQUITH LIMITED

KING EDWARD HOUSE, NEW ST., BIRMINGHAM Phone: Midland 3431. Also at LONDON Phone: Trafalgar 7224 & GLASGOW Phone: Central 0922



...as sound as a Gloucester casting!



Differential Cage in Malleable Iron. Weight 8½ lbs.

"As sound as a Gloucester Malleable casting" is no mere phrase. It is the result of a wealth of traditional skill and technical knowledge at every stage of production. Raw materials, melting and pouring processes, sand practice, moulding and core making, fettling and setting, all are exactly controlled to ensure castings that will measure up to to-day's exact engineering needs.

They are also accurately set under modern presses, using dies made to the limits required, to ensure that castings can be machined without costly delays.

Always consult Gloucester at the designing stage — even before.

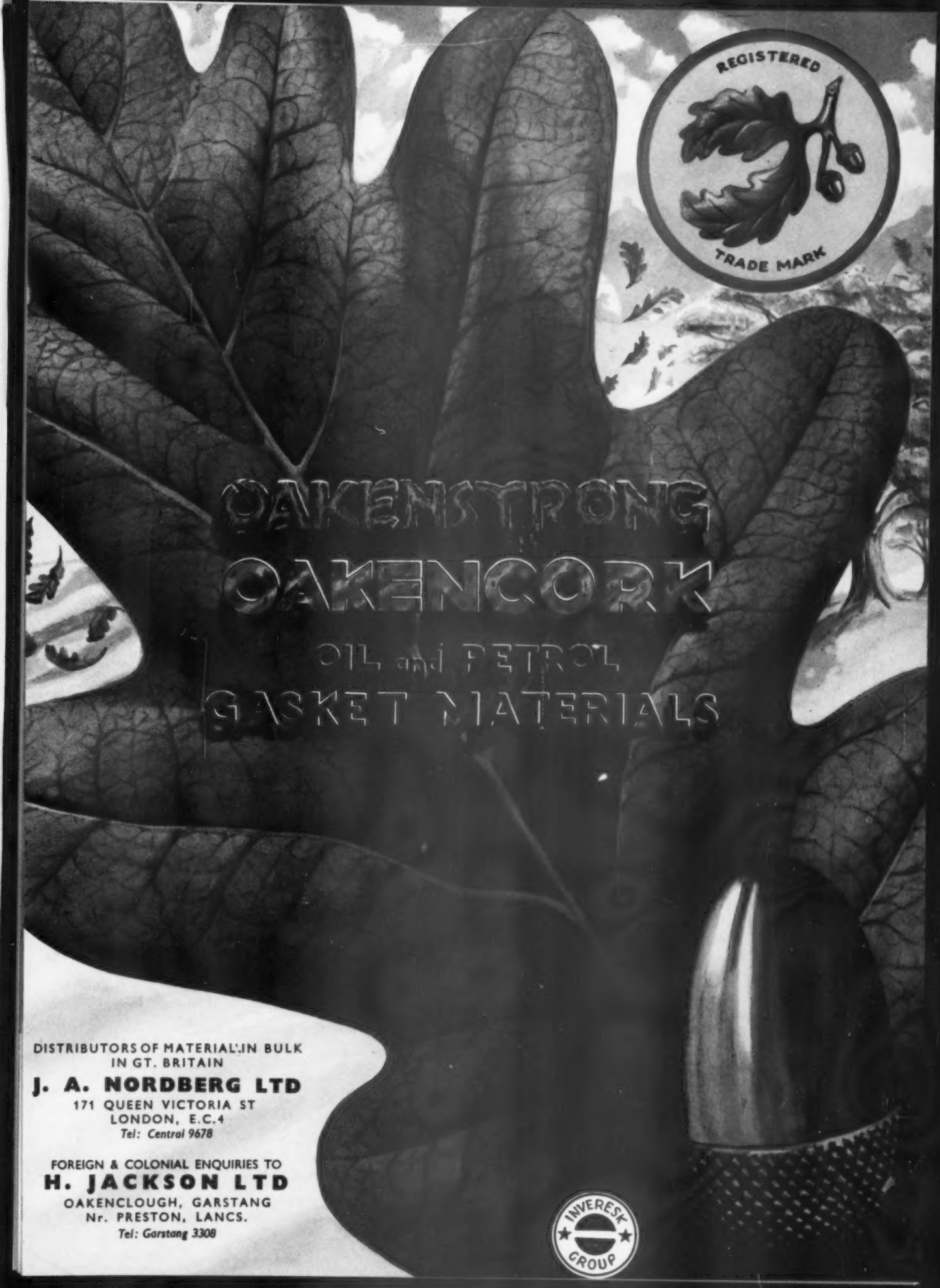
Vehicle Steering Box in Malleable Iron. Weight 6¾ lbs.

A typical Gloucester Malleable specification.

Gloucester Blackheart Malleable		*Gloucester Lamellar Pearlitic Malleable*	
Elongation	18%	Elongation	5%
Yield Point	12 tons	Yield Point	24 tons
Tensile Strength	25 tons psi	Tensile Strength	35 tons psi

GLOUCESTER

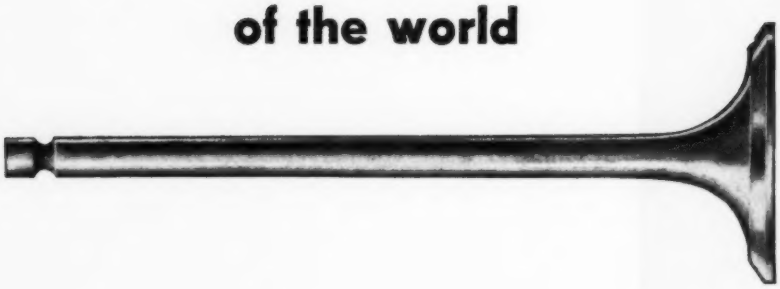
Gloucester Foundry Ltd., Emlyn Works, Gloucester · Telephone: Gloucester 23041 · Telegrams: 'Pulleys' Gloucester
(A subsidiary of the Gloucester Railway Carriage & Wagon Co. Ltd.)



Taste of Quality

You'll find **FARNBOROUGH** *valves*

going to all the continents of the world



AUSTRALIA
BURMA
CANADA
DENMARK
EAST AFRICA
HOLLAND
INDIA
MALAYA
NEW ZEALAND
NORWAY
RHODESIAS-NYASALAND
SOUTH AFRICA
SWEDEN
URUGUAY
U.S.A.
ETC.

FARNBOROUGH ENGINEERING CO. LTD · FARNBOROUGH · KENT

Tests of Quality

Major Events—January to August 1959

DATE	MEETING	RESULT
Jan. 10th	New Zealand Auckland Grand Prix	Cooper-Climax 1st, 2nd, 3rd.
Jan. 25th	Monte Carlo Rally : Charles Faroux Trophy : Class Award over 2,000 cc. : Coupe des Dames : R.A.C. Challenge Trophy : Class Award up to 1,000 cc.	Jaguar 3-car team. Jaguar 1st & 2nd. Austin A.40 1st. Austin A.40 1st. Austin A.40 2nd.
Feb. 7th	New Zealand, Teretonga Race	Cooper-Climax 1st & 3rd.
Feb. 8th	Canada: Winter Rally, Ladies Cup	Austin A.40.
Feb. 26th	Italy: Sestriere Rally: Touring Cars 500-1,000 cc. Touring cars over 1,600 cc.	Austin-Healey Sprite 1st. Jaguar 3-4 1st.
Mar. 15th	France, Lyon-Charbonieres Rally: Ladies Cup	Austin A.40.
Mar. 21st	U.S.A. Sebring: Touring Cars Class 4	Austin-Healey Sprite 1st, 2nd & 3rd.
Mar. 30th	Ireland International Rally: Ladies Trophy	Morris Minor 1000.
Mar. 30th	Goodwood : Levant Cup : Sussex Trophy : Production Saloon Car Race	Cooper-Climax 1st. Lister-Jaguar, 1st & 2nd. Jaguar 3-4 1st, 2nd & 3rd.
Mar. 30th	Mallory Park : Sports Cars over 1,200 cc. : Formula Libre	Lister-Jaguar 3-4, 1st. Lister-Jaguar 3-4, 1st.
Apr. 11th	Oulton Park : British Empire Trophy : Sports cars over 1,500 cc.	Cooper-Climax, 2nd. Cooper-Monaco, 1st. Lotus-Climax, 3rd. Lister-Jaguar, 4th.
Apr. 18th	Aintree : Sports Cars over 1,500 cc. : 2,000 cc. Class : Saloon Car Race : Scratch Race Saloon Cars 1,600-2,600 cc.	Lotus-Climax 2nd. Lister-Jaguar, 3rd. Lotus-Climax, 1st. Cooper-Climax, 2nd. Jaguar 3-4, 1st, 2nd & 3rd. Jaguar 2-4, 2nd.
Apr. 26th	Italy, Syracuse Grand Prix: Formula 2	Cooper-Climax 3rd.
May 3rd	Holland, Tulip Rally, General Classification Class F: over 2,600 cc.	Jaguar 3-4, 1st. Jaguar 3-4, 1st & 2nd.
May 2nd	Silverstone: International Trophy, Formula 2 Saloon Cars, 2,000-3,000 cc. Sports Cars, 1 litre Sports Cars, 2 litre Production Touring Cars, General Class Production Touring Cars, over 2,000 cc. International Touring Cars, 1,300-1,600 cc.	Cooper-Climax, 1st & 3rd. Lister-Jaguar, 3rd. Cooper-Climax 1st. Lotus-Climax, 2nd & 3rd. Jaguar 3-4, 1st, 2nd & 3rd. Jaguar 3-4, 1st, 2nd & 3rd. M.G. 2nd.
May 10th	Monaco Grand Prix	Cooper-Climax, 1st & 5th.
May 16th	Pau Grand Prix: Formula 2	Cooper-Climax, 1st, 2nd & 4th.
May 24th	Targa Florio: 1,100 cc. Sports Class	Austin-Healey Sprite 2nd.
May 31st	Dutch Grand Prix	Cooper-Climax, 2nd & 3rd. Lotus-Climax, 4th
July 5th	French Grand Prix, Rheims	Cooper-Climax 3rd.
July 18th	British Grand Prix, Aintree Sports cars over 2 litres Sports cars 1,400 cc. to 2 litres	Cooper-Climax, 1st & 3rd. Lister-Jaguar, 2nd, 3rd & 4th. Lotus-Climax, 1st & 3rd. Cooper-Climax 2nd.
Aug. 23rd	Portuguese Grand Prix (Subject to official confirmation)	Cooper-Climax 1st & 2nd.

successes with
pistons & rings
by

TRADE MARK

THE BRITISH PISTON RING CO. LTD., COVENTRY, ENGLAND

. . . and in our Jubilee year too!

The vast majority of new cars
at the Motor Show
have Ferodo Brake Linings
as original equipment

FERODO Brake Linings · Disc Brake Pads

FERODO LIMITED · CHAPEL-EN-LE-FRITH *A member of the Turner and Newall Organisation*

Special Alloy

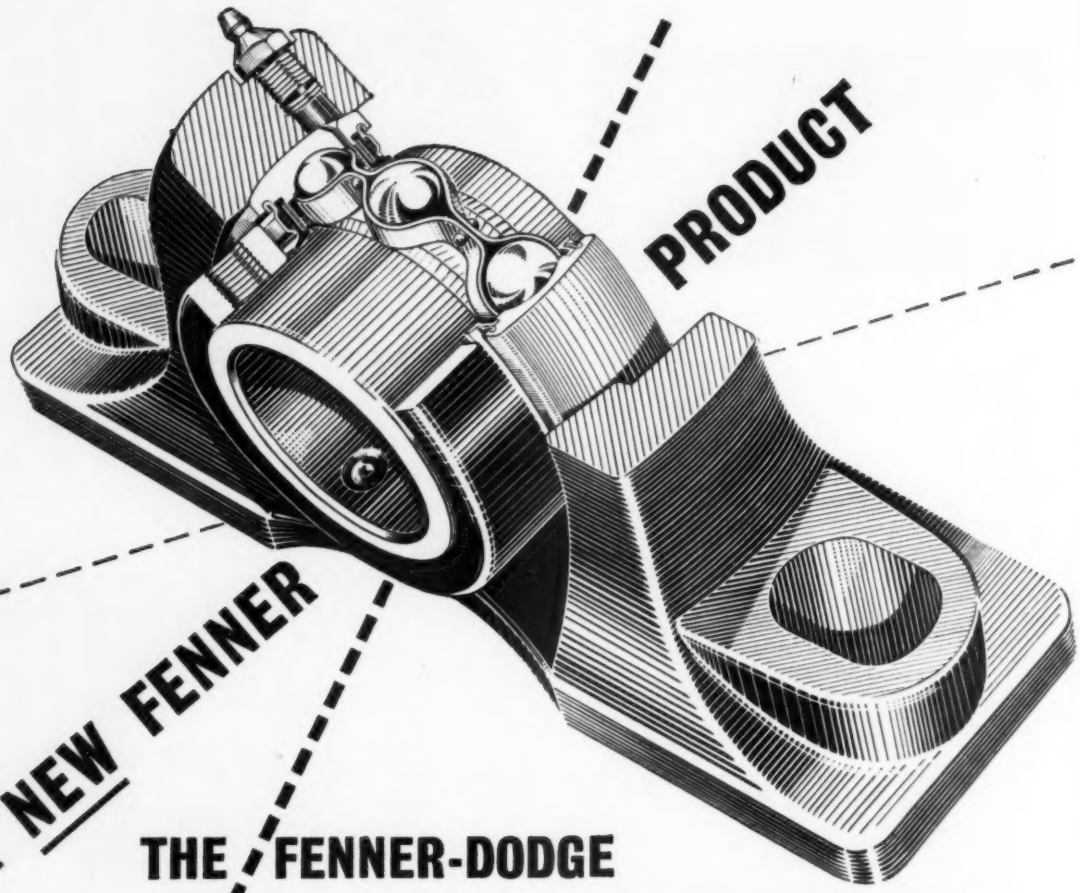
STEEL BARS

by

FIRTH BROWN

ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

THOS FIRTH & JOHN BROWN LIMITED SHEFFIELD · ENGLAND



A NEW FENNER PRODUCT

THE FENNER-DODGE SC BALL BEARING PLUMMER BLOCK

with these special 5 star features :-

★ A sealed bearing with relubrication facilities giving longer life under arduous conditions.

★ Easy to fit housing designed to give adequate spanner room and elongated bolt holes allow lateral adjustment.

★ Separate collar provides bearing to shaft fixing without distortion of inner race.

★ Special seal designed for low frictional losses and keeps grease in and dirt out.

★ Deep groove ball bearing with long inner race distributes loads over greater shaft area, and is fully self aligning.

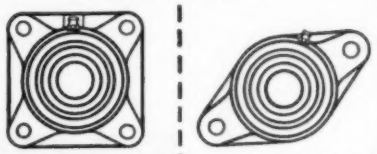
Send for leaflet 250/19

Fenner

J. H. FENNER & CO. LTD., MARFLEET, HULL

BRANCHES AT: BELFAST, BIRMINGHAM, BRADFORD, BRISTOL, BURNLEY, CARDIFF, GLASGOW, HULL, LEEDS, LEICESTER, LIVERPOOL, LONDON, LUTON, MIDDLESBROUGH, MANCHESTER, NEWCASTLE-ON-TYNE, NOTTINGHAM, SHEFFIELD, STOKE-ON-TRENT.

ALSO AVAILABLE IN



4 BOLT FLANGE BEARING | 2 BOLT FLANGE BEARING

LARGEST MAKERS OF V-BELT DRIVES IN THE COMMONWEALTH.

FINE STEELS

TOLEDO

FOR ALL ENGINEERING AND PRODUCTION PURPOSES

WRITE FOR LITERATURE AND STOCK LIST

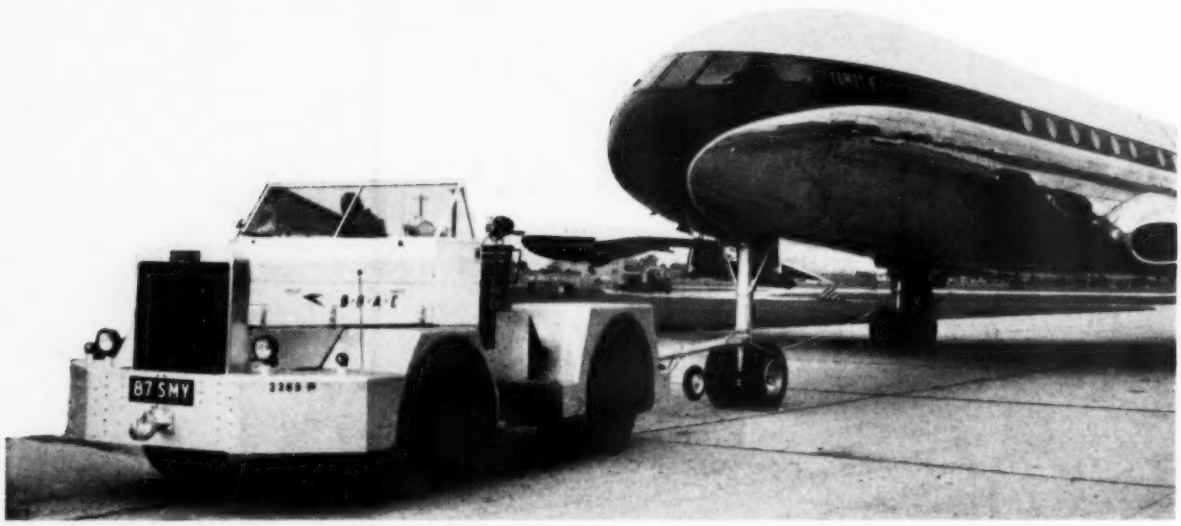
ANDREWS TOLEDO LTD.

TOLEDO STEEL WORKS · SHEFFIELD 3

TELEPHONE 23274

A.T.103.

KIRKSTALL AXLES



MERCURY AIRTUG

WITH KIRKSTALL AXLES
MOVES THE COMET 4

KIRKSTALL FORGE ENGINEERING LIMITED

LEEDS 5, ENGLAND

TEL: HORSFORTH 2821 (8 LINES)
CABLE: FORGE, KIRKSTALL

MIDCYL RESEARCH

helps smooth out problems from the start

The Auto Engineer finds it better to start right by calling in Midcyl Research on such of his problems as are associated with Cylinder Blocks, Cylinder Heads, Camshafts and Brake Drums.

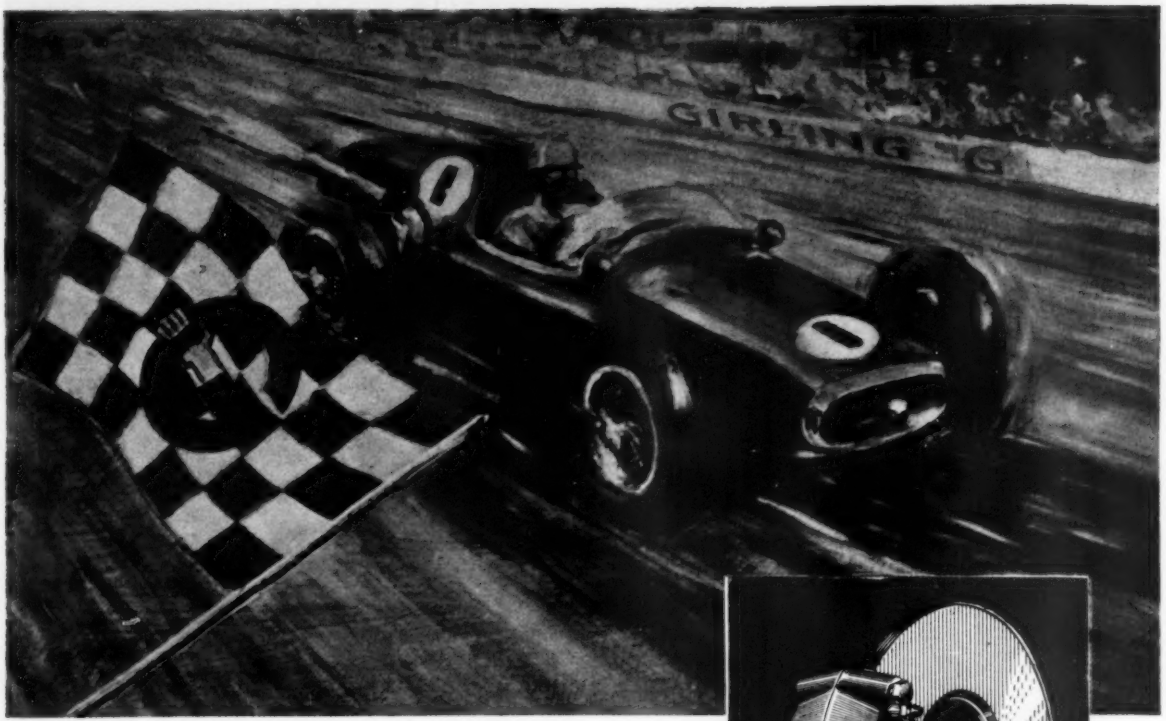
MIDCYL

THE MIDLAND MOTOR CYLINDER CO. LTD., SMETHWICK, STAFFS

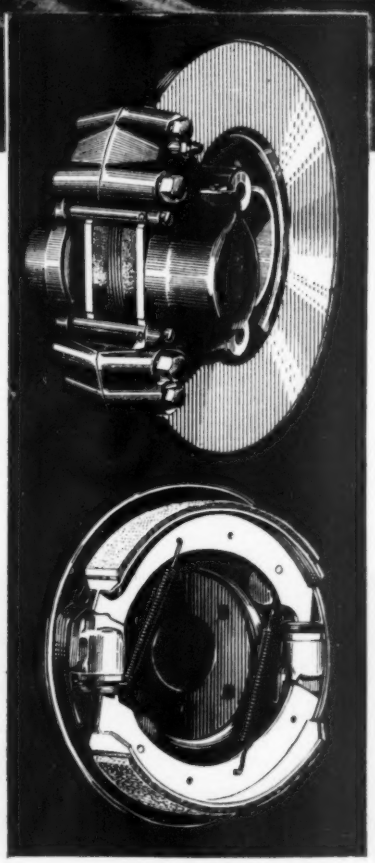
M-W.81

Right from the start—

It's been a great year for GIRLING



1959 a great year for Girling. A whole host of successes for Girling-equipped cars on the racing circuits of the world —Monaco, Le Mans, Nurburgring, Aintree, and many more. 1959, a great year, too for the choice of Girling equipment—disc brakes, drum brakes, dampers—on an impressive list of new models from manufacturers in Britain and abroad.

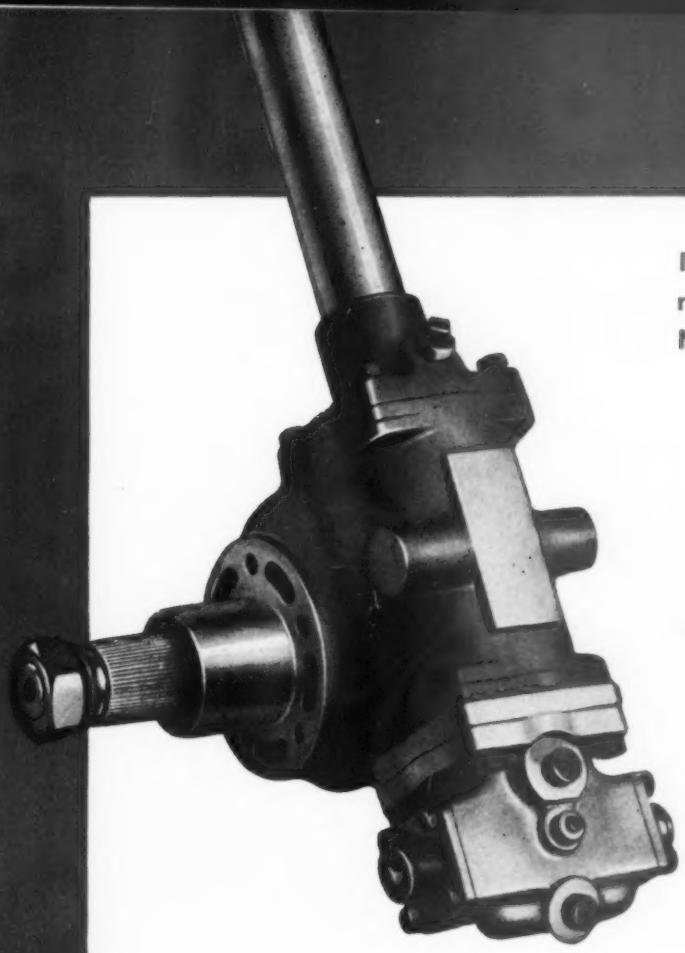


GIRLING

BRAKES and DAMPERS

STAND **296** MOTOR SHOW EARLS COURT OCTOBER 21st—31st

GIRLING LIMITED · KINGS ROAD · TYSELEY · BIRMINGHAM



Interchangeable, on the same mounting, with the standard Marles manual gear unit.

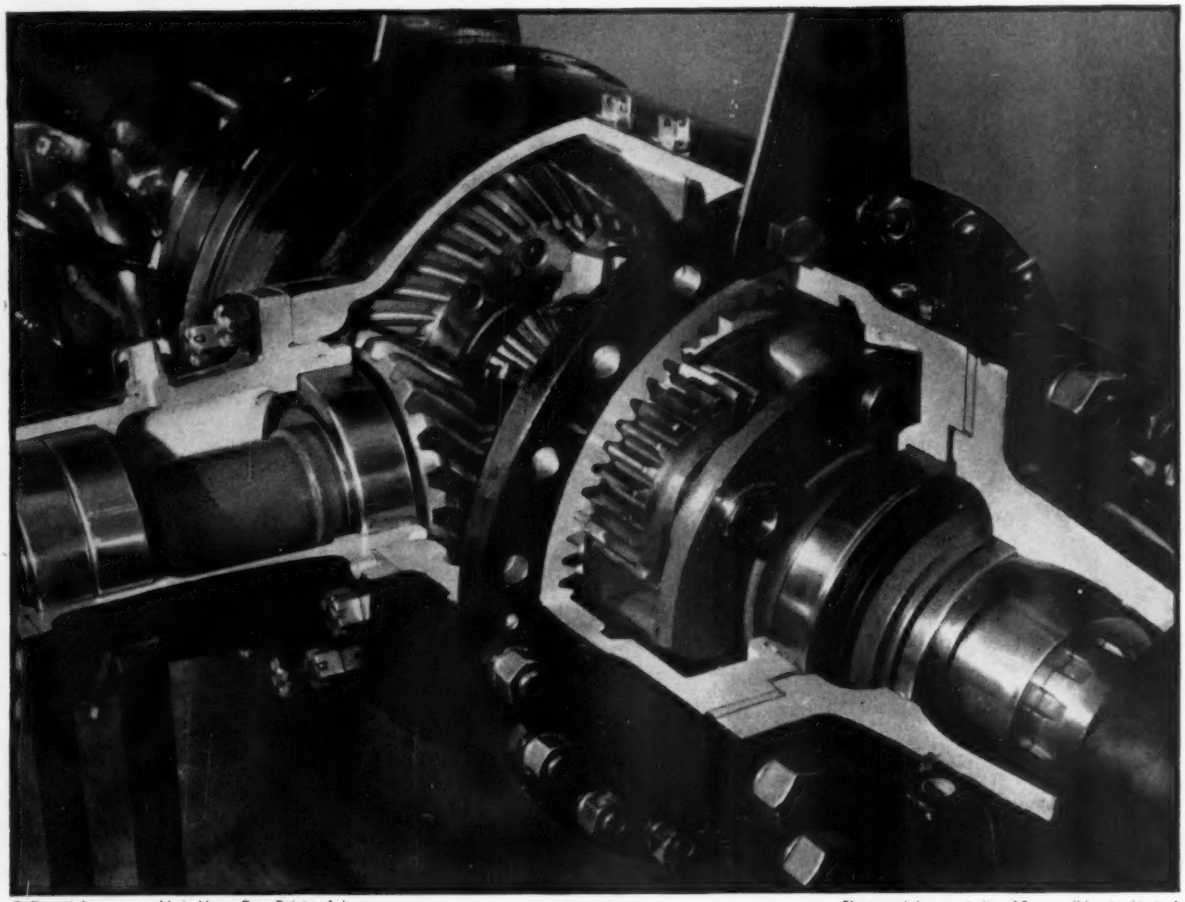
THE TYPE 3 'UNIVERSAL' UNIT

Illustrated above is the Type 3 'Universal' steering gear which incorporates the hydraulic control valves mounted upon our type '861' manual gear. This is for use with a separate power pump and with power cylinders operating on the steering linkage. Further particulars will be sent on request.

ADAMANT ENGINEERING CO. LTD.,
THE AERODROME, WOODLEY, Near READING.
Sole proprietors of the Marles Steering Company Ltd.
Telephone: Sonning 2351 Telegrams: Adamant, Reading

MARLES

High Quality DROP FORGINGS



Differential gear assembly in Heavy Duty Driving Axle

Photograph by permission of Scammell Lorries Limited

for the automobile and transport industries

by

FIRTH - DERIHON

SHEFFIELD & DARLEY DALE

A 16mm. Colour Film with sound commentary, entitled "Drop Forgings in Alloy Steels," is available on request

THE FIRTH-DERIHON STAMPINGS LIMITED, SHEFFIELD.

THE SMALL CYLINDER

THAT DOES A BIG JOB

To meet the demand for a small, powerful and compact air cylinder Schrader's have added to their already representative range a new midget type. This is a double-acting cylinder of 1″ bore, with a neck mounting thread for easy assembly in any position. The cylinder and piston are of non-corrodible brass and the general construction is designed to give long trouble-free service under fast, arduous conditions. It is ideally suited for operating jigs and fixtures, transfer and special purpose machines. This cylinder can be supplied from stock with the following piston strokes, 1″, 2″, 3″, 6″, 9″ and 12″.

Compact overall size permits mounting in the minimum space.

●

Popular 1″ dia. neck mounting thread complete with lock nut. Fits standard 1″ dia. bored holes.

●

Cartridge type bronze bearing and piston rod seal, replaceable without dismounting cylinder.

●

Synthetic rubber "U" cup piston seals—self adjusting.

Schrader AIR CYLINDERS

To: **A. SCHRADER'S SON**, Air Control Products Dept. AE, **829 TYBURN ROAD, ERDINGTON, BIRMINGHAM, 24**

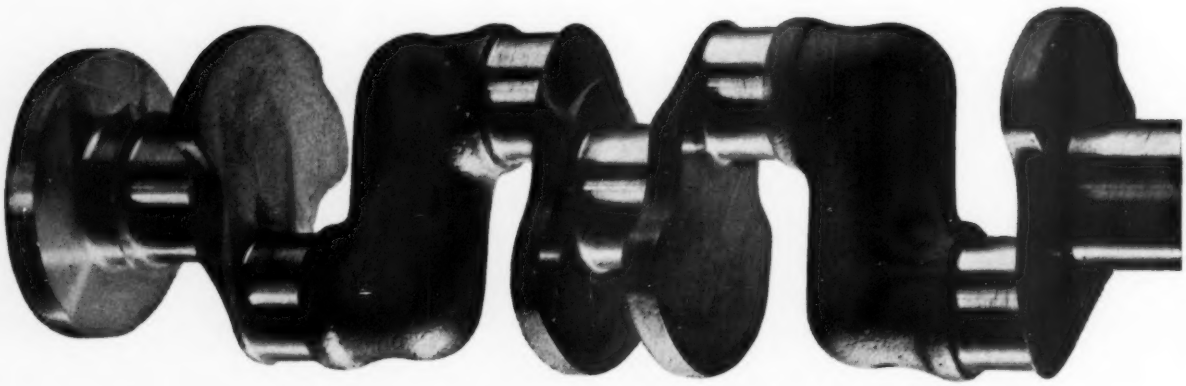
Please send details of Schrader Midget Air Cylinders

NAME.....

ADDRESS.....

19

A new approach to



cast crankshafts in s.g. iron

Darcast announce the installation of plant for the quantity production of precision cast crankshafts.

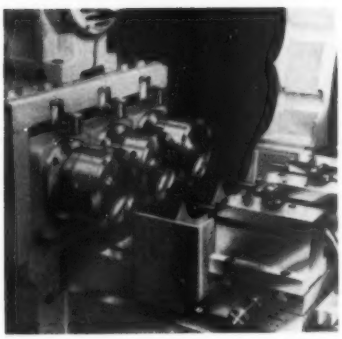
quantity	From tens to thousands per week.
precision	Machining allowances down to as little as 0.030" on journals and crankpins.
material	S.G. (nodular) iron ; min. tensile 35 tons p.s.i. Elongation 2-4%.
service	Prototype to production, from one of Europe's most highly mechanised foundries.

Dartmouth Auto Castings Ltd

Dartmouth Road, Smethwick 40, Staffs

AUTOMOBILE ENGINEER

CONTENTS



THREE - SPINDLE FINE - BORING MACHINE SET UP FOR BORING AND FACING GEAR BLANKS TO LIMITS OF 0·0005 IN FOR DIAMETER AND 0·0002 IN FOR CONCENTRICITY. THE FLOOR - TO - FLOOR TIME PER COMPONENT IS 10 SECONDS

363 Editorial *Commercial Vehicle Suspension*

364 Saginaw Power-assisted Steering *Simplicity and good response characteristics obtained with the new rotary valve unit*

369 Solution of Supercharged Engine Cycles *A simplified approach involving the application of thermodynamic charts* S. E. BONAMY

372 Rotary Exhausters *Some notes on the development and construction of Clayton Dewandre vacuum brake equipment*

376 Aluminium Bronze *Metallurgical considerations relating to the use of this alloy for high temperature service* G. FITZGERALD-LEE

381 Gas Sampling Valve *Device for use in the study of the complex changes that take place in the combustion chamber of an automobile engine*

382 Recent Foreign Publications *Brief reviews of current technical books*

384 New British Cars *Summary of the noteworthy features of the Daimler SP250 and Ford Anglia, Popular and Prefect*

390 Fine Boring and Fine Turning *Applications of Boneham and Turner equipment demonstrate versatility of the process in production*

394 The American Small Cars *Preliminary information on the Chrysler, Ford and General Motors products designed to fill the demand for more compact vehicles*

397 Spray Deposition of Metal *Salvage of production rejects by the Sprabond Wire process* J. ALAN SHEPPARD

398 Sealing Castings *Ray-Heet continuous-flow plant, installed in the new Ford factory, for painting castings for the engine and transmission units of all classes of vehicles*

402 Honing Developments *Automatic machines suitable for incorporation in transfer-type production lines enable economies to be made in finishing operations*

Published the second Wednesday in every month by ILIFFE & SONS LIMITED
*Dorset House, Stamford Street, London, S.E.*1
Telephone · Waterloo 3333 (60 *lines*)
Telegrams · Sliderule, Sedist London
*The annual subscription inland and overseas is £*3 0*s* 0*d including the special number*
Canada and U.S.A. $8.50

© ILIFFE & SONS LIMITED, 1959

BRANCH OFFICES
Coventry · 8-10 Corporation Street
Telephone · Coventry 25210
Birmingham · King Edward House, New Street, 2
Telephone · Midland 7191
Manchester · 260 Deansgate, 3
Telephone · Blackfriars 4412 *and Deansgate* 3595
*Glasgow · 26B Renfield Street, C*2
Telephone · Central 1265

Which lamp ?

To get the right light on the subject is half-way to success; the rest is a matter of performance.

And the SKF organisation certainly doesn't believe in hiding its light under a bushel. With an exchange of technical information on applications that is international, Skefko have either met your problem before or can draw on the best in research and manufacturing resources to settle it for good—in fact for *your* good !

SKF

THE SKEFKO BALL BEARING COMPANY LIMITED · LUTON · BEDS

THE ONLY BRITISH MANUFACTURER OF ALL FOUR BASIC BEARING TYPES: BALL, CYLINDRICAL ROLLER, TAPER ROLLER & SPHERICAL ROLLER

G198

Editor *T. K. Garrett, A.M.I.Mech.E. A.F.R.Ae.S.*
Editorial Staff *F. C. Sheffield (Associate Editor)*
A. Baker, B.Sc., A.M.I.Mech.E.

DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Commercial Vehicle Suspension

FOR many years there has, of course, been general dissatisfaction with commercial vehicle suspension, but, so far, the cost and complexity of systems that give better performance has been a barrier to progress. Great hopes have been held out for air suspension, and it has been felt that operators would tolerate the additional expense involved because it is at least to some extent offset by lower cost of vehicle maintenance and construction, by virtue of a reduction in fatigue loading of structural components. Moreover, the advantages in respect of improved performance obtained by the adoption of air suspension are a great asset in many other respects for certain types of commercial vehicle operation.

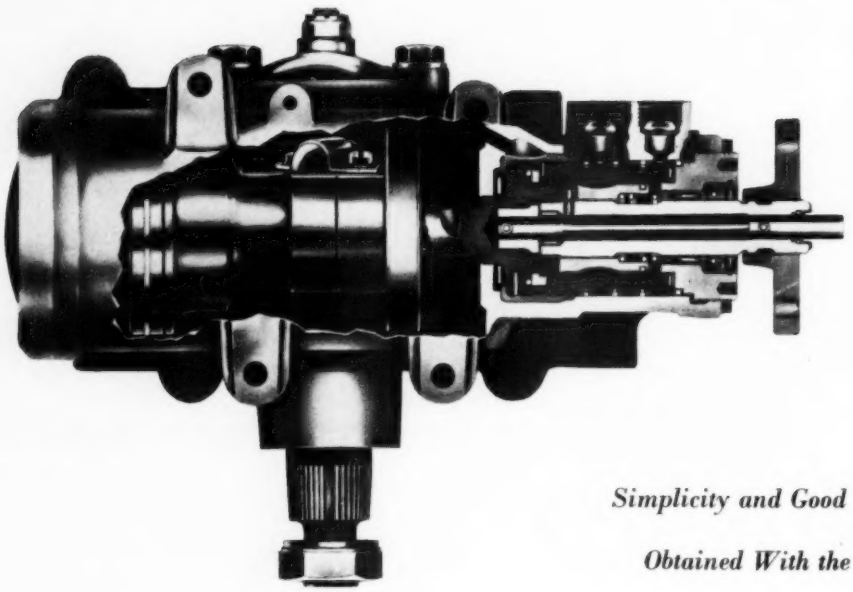
However, enthusiasm for air springing has tended to wane, not so much on account of major shortcomings in respect of its performance, but rather because of minor defects that sometimes occur, for example, the malfunctioning or complete failure of levelling valves owing to the freezing of moisture in them. On the other hand, operators of some types of vehicle, notably tankers, are still very interested in this form of suspension, since the damage that may occur to these rigid vehicles when operated with normal semi-elliptic springs represents a serious problem. Trailer operators, too, because of the very large differences between the laden and unladen weights of their vehicles, are attracted by air suspension; in this connection, it is pertinent to note that with semi-trailers, the suspension of the tractor ought to be matched to that of the trailer; this is a subject that merits more attention than it has hitherto received.

So far as vehicle chassis are concerned, there is a noticeable trend towards the employment of semi-elliptic springs—to support the unladen weight of the vehicle—in conjunction with air springs for automatic adjustment to compensate for variations in load. At first sight, the employment of two springs where one was previously used seems hardly likely to be acceptable, especially since the additional spring system is costly. However, if air suspension is to be used at all, some form of axle location is essential, and a leaf spring is at least as simple a mechanism for the purpose as are any of the systems of links generally employed.

A compromise can be effected by mounting a single spring, comprising perhaps only two leaves, centrally above the axle casing. This provides adequate lateral location, but can require at least one additional link to prevent the axle from swinging about its central vertical axis. A big advantage of this arrangement is that it considerably reduces the unsprung weight.

The subject of unsprung weight reduction for commercial vehicles is well worth further study. Legal limits in respect of axle loadings are determined partly by the ability of roads to withstand the local loading transmitted through the vehicle axle and wheels. However, the maximum value of this local loading on the road does not necessarily bear any relationship to the static loading of axles in general: it is determined by the dynamic load applied by the axle under wheel hop conditions superimposed on the static load and, for a given spring rate and laden weight, may vary considerably as between vehicles having axles of different unsprung weights. It follows that if more were known about this subject, it might be possible to formulate new regulations in respect of axle loading, which would allow larger loads to be carried by vehicles having suspension systems with low unsprung masses.

In this connection, an interesting trend apparent at the recent Frankfurt Show was towards the employment of independent front suspension, with coil springs, for commercial vehicles of about 2-tons load carrying capacity. Of three new vehicles in this class, only one had a conventional channel-section frame. The second had a box-section under-frame, and was of integral construction, while the third had a box-section frame of the ladder type. It appears likely that, just as car manufacturers when they first adopted independent front suspension found they needed frames having greater torsional stiffness, commercial vehicle manufacturers are having the same experience. In short, if this trend continues to gain momentum, it may well be accompanied by a revolution in commercial vehicle frame design, even extending to the heavier classes.



A spool type valve is employed in the Saginaw steering unit, but it is of the rotating type instead of the more conventional axial motion type which has been used earlier for a number of power-assisted steering gear units

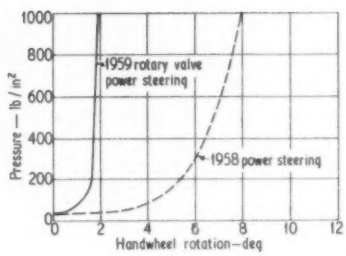
Simplicity and Good Response Characteristics

Obtained With the New Rotary Valve Unit

SAGINAW POWER-ASSISTED STEERING

ON the 1959 Cadillac, Oldsmobile, Buick and Pontiac cars, the power-assisted steering gear offered is the Saginaw rotary valve unit, but under the names: In-Line Power Steering, Roto-Matic Steering, New Easy Power Steering, and Wonder-Touch Steering respectively. It was designed with a number of objects in view. Principally, these were the achievement of instantaneous hydraulic response, the elimination of friction between the steering wheel and the hydraulic valve, reduction of the number of seals that could contribute to external leakage, and economies in respect of the number of components and overall size and weight. Details of the 1959 unit have been given, to the Society of Automotive Engineers Inc., by Philip B. Zeigler, of Saginaw Steering Gear Division of General Motors Corporation.

Fig. 3. Comparison between the response characteristics of the 1958 and 1959 power-assisted steering units. The rapid response of the later model is mainly due to the employment of the rotary, spool type valve



The pump

For the 1959 system, the pump has been completely redesigned, Fig. 1, although it is still of the positive displacement vane type, which has been used since 1952. One of the reasons for the redesign was to make the pump smaller in bulk, so that it could be more easily installed on the chassis. Another aim was at obtaining a larger delivery rate to match the more rapid steering response obtainable with the new valve.

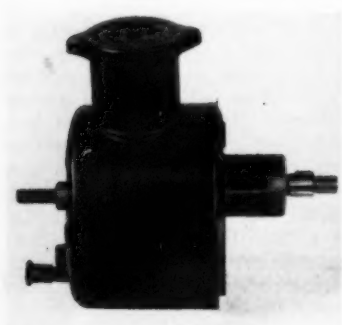


Fig. 1. The pump is housed within the oil reservoir, which has a twist-lock type of filler cap

Although the requirements of smaller bulk and higher capacity seem to be incompatible, both objectives have been attained. This has been done by increasing the size of the rotor-and-vane assembly, to obtain the higher output, and by submerging the working parts within the reservoir, instead of having a separate reservoir on top. The latter measure has, of course, reduced the overall size of the unit. As a result of these design changes, the capacity has been increased from 1·5 gal/min under engine idling conditions, to 1·75 gal/min under the same conditions. This represents an increase of 17 per cent in output, relative to that of the earlier pump.

The output at low speed conditions of operation is, of course, important for parking. On the other hand, a much lower output is needed from the pump at high vehicle speeds: if the output of the unit were to increase in proportion to its speed, the rate of delivery would probably rise to about 20 gal/min. This, obviously, would be impracticable, so a flow-control valve is employed to restrict output, the surplus oil being recirculated through the pump. For the 1959 unit, the flow-control valve has been redesigned to give what the manufacturers term a *drooping flow characteristic:* in other words, the delivery is actually lower at high speeds

than under idling conditions. The benefits thus obtained include lower power absorption, lower temperatures and, consequently, an improvement in respect of the conditions under which components such as oil seals operate. It is also claimed that the output of the pump does not fall off as oil temperature increases. This, of course, is a particularly important characteristic for operation in parts of the country where the climate varies widely, as between different seasons of the year, or where the differences between day and night temperatures are great.

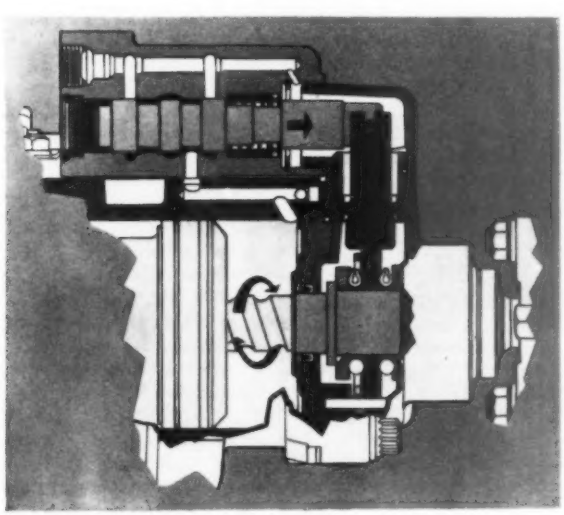
Steering unit

Without doubt, the most obvious disadvantage that any power steering unit may have is poor hydraulic valve response. The design limitations of the spool-type valve for steering units have hitherto dictated that it be actuated by a screw thread or similar mechanism to convert the rotary motion of the steering wheel into linear motion of the spool. General Motors, as well as some of its competitors, have tried to multiply this movement by a lever, but it has been found that much of this multiplication has been lost because of deflection of the mechanism itself—Fig. 2 is an example of the typical spool valve operated by a screw and nut, with the linear movement multiplied by a simple lever. After consideration of earlier designs, it was concluded that, to obtain instantaneous response, the valve must be the first element under the steering wheel, and must also be directly connected, so that the rotary action of the wheel immediately effects the rotatory motion of the valve.

This arrangement of the valve also eliminates all friction between the steering wheel and the valve, since there is no operating mechanism for valve operation. Thus, there is no lag or transition due to cutting in and out of valve operation, and a design can be evolved with which the vehicle can be steered with very little effort. Steering effort can also be adjusted, by the designer, to suit the individual customer's requirements for the vehicles he has designed.

In the laboratory, valve response can be gauged simply by measuring the pressure build-up in the steering gear, as a function of the steering wind-up, with the steering gear output shaft locked. Fig. 3 compares the results of such tests on 1959 gears and on a 1958 gear. It can be seen that, on this test, the pressure build-up in the 1958 Saginaw steering gear begins at about 2 deg rotation of the steering wheel, and the pressure does not reach 1,000 lb/in^2 until

Fig. 2. A typical example of a valve actuated by a lever mechanism



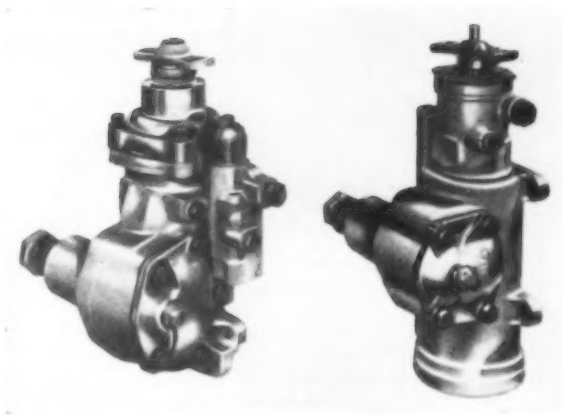


Fig. 4. On the left-hand side is the 1958 power-assisted steering gear, and on the right is the 1959 unit. It is obvious that the later model is simpler, lighter and more compact, and that the number of hydraulic seals and other components has been reduced

the wheel has been rotated approximately 7 deg. With the 1959 Saginaw gear, pressure starts to build up at 0·25 deg rotation of the wheel, and attains a value of 1,000 lb/in^2 at approximately 2 deg rotation.

From a practical standpoint, an 0·005 in gap between the edges of the land and of the port in the open-centre type valve, gives about the best compromise between pressure

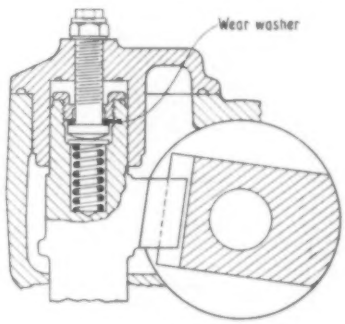


Fig. 5. Automatic adjustment for wear between the rack teeth on the nut and the quadrant on the pitman shaft is obtained by the employment of a soft washer and coil spring arrangement as in this illustration

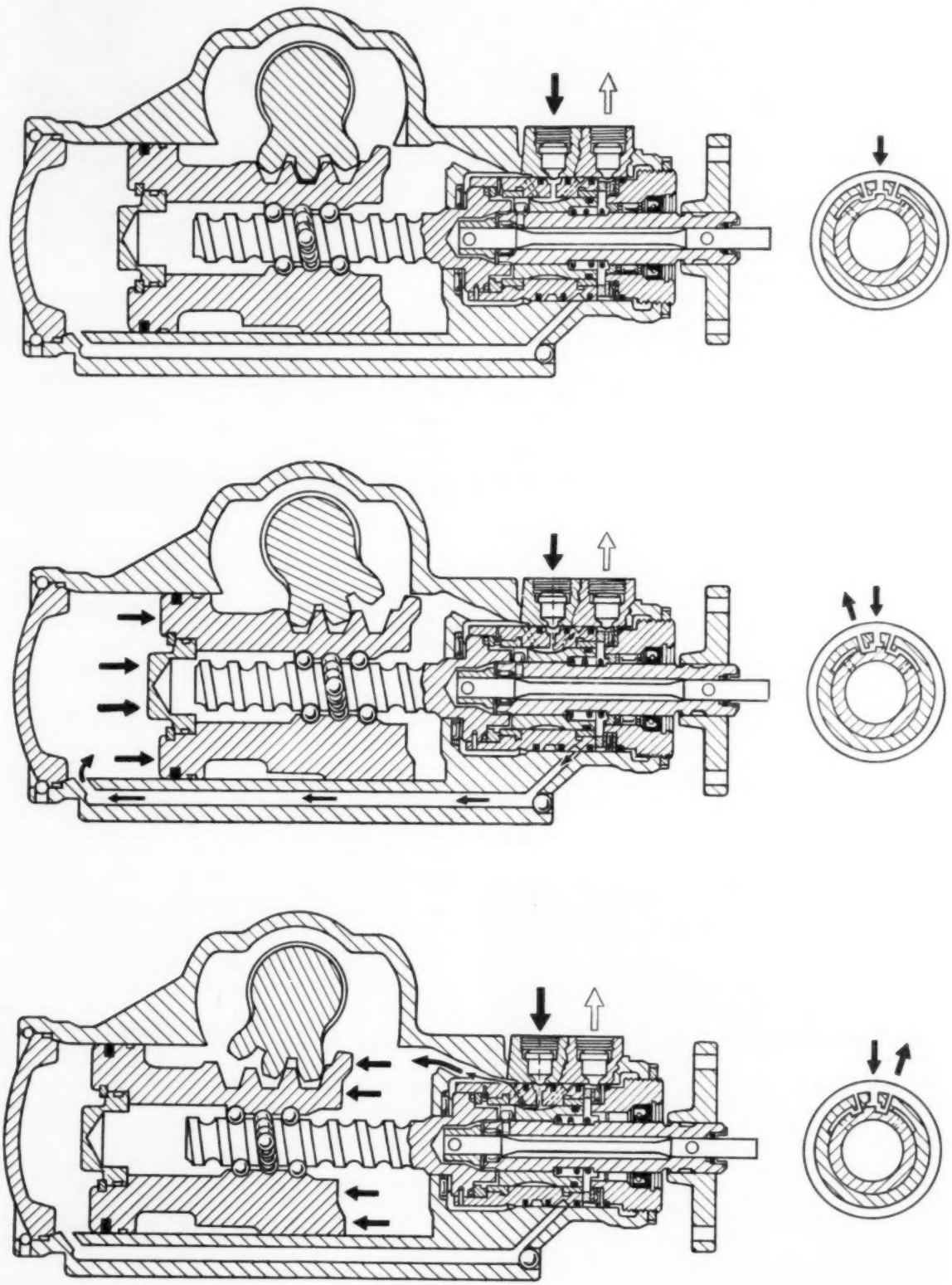
build-up and required free flow capacity. The advantage in respect of performance of the valve with this 0·005 in gap can be seen from the following figures. To start the pressure build-up, the rotary valve requires 0·037 in movement, which represents the $\frac{1}{4}$ deg rotation of a 17 in diameter wheel, as already mentioned, compared with 0·300 in movement, or the 2 deg of the same handwheel, with a conventional spool valve with lever type actuation.

Avoidance of leakage has always been a major problem in the production of hydraulic units. In the Saginaw rotary valve gear there are now a total of 9 external seals, as compared with 18 in the 1958 design. This reduction was made possible by designing the steering gear housing to receive all the working parts, in a concentric arrangement. As can be seen from the comparison of the two units, in Fig. 4, the new arrangement eliminates the sealing that would be required for an externally attached valve and all its related components.

Much design and development work has been done to reduce the number of components within the unit. Such a reduction does not necessarily lighten a product but, in this case, it was possible to achieve both simplification and weight reduction. The 1958 unit has 116 pieces, and weighs 28$\frac{1}{2}$ lb, but the 1959 one has only 99 pieces, for a weight of 27$\frac{1}{2}$ lb, and is 0·83 in shorter and so is now easier to install.

FIG. 7. FLOW DIAGRAM FOR THE ROTARY VALVE TYPE STEERING GEAR

The upper diagram shows the valve in the neutral position; in the central one it is in the right-hand turn position, and in the lower diagram it is set for a left-hand turn. The return flow passes initially from the centre of the spool, through a radial hole to its periphery and thence to the outlet



Another outstanding feature of the new system is the automatic adjustment for wear between the rack teeth on the nut and the teeth on the quadrant on the pitman shaft. This arrangement is illustrated in Fig. 5. Basically, the device is simply a soft washer interposed between a nut screwed into the end of the pitman shaft and the head of an adjustment screw locked in the casing. As this washer wears, the clearance is taken up by a compression spring and the teeth are moved into closer engagement. As a further improvement, the worm-nut in the Saginaw steering gear has a helical ball-track with a curved pitch line, Fig. 6, the components being selectively assembled so that, over the mid portion of its travel, where backlash is particularly undesirable, there is a preload between the balls, nut and worm.

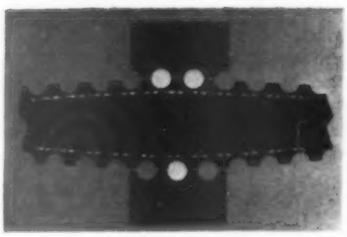


Fig. 6. Diagram showing how the worm is barrelled to give a pre-load in the central position, where the rate of wear is inevitably the greatest

Layout and construction

Basically, the steering unit, which is of the worm-and-nut type, is constructed as follows. The power assistance piston is formed by a nut which is bored axially and internally grooved helically to receive the worm and recirculating balls. Rotation of the worm causes the nut to move axially, and the reaction on the worm is taken by two thrust bearings, one at each end of the valve assembly. A toothed rack is machined along part of the periphery of the nut, and this meshes with a toothed segment mounted on the pitman shaft.

The connection between the worm and the steering stub-shaft, which is carried in the valve assembly, is a torsion bar spring. Thus, if the reaction to the steering load is very light, the manual effort at the wheel is transmitted directly to the worm. The greater the resistance to the turning of the steering wheel, the larger is the deflection of the torsion bar, and this deflection causes the spool of the rotary valve to turn relative to the sleeve in which it is housed. A torsion bar was chosen as a means of centring the valve because it is simple, positive, and provides a centring force proportional to the angle of deflection. Obviously, by suitable choice of torsion bar size and port arrangement, the unit can be adjusted to give almost any performance characteristics.

As can be seen from Fig. 7, the torsion bar is carried in an axial hole in the steering stub-shaft, and two pegs, one at each end, connect it to the steering stub-shaft and the worm. The cylindrical spool of the valve is fitted over the stub-shaft, and the connection between these two components is a ball-ended pin pressed into a radial hole in the shaft so that the ball-end of the pin registers in a slot in one end of the spool. This arrangement allows for misalignment between the spool, the sleeve that surrounds it, and the steering stub-shaft, and thus prevents binding of the spool in the sleeve. There is a clearance of 0·0004 and 0·0008 in between the spool and sleeve, and this clearance is obtained by selective assembly.

The sleeve is fixed to the worm and rotates with it. Drilled radially in the sleeve are the inlet port from the pump and the two outlet ports, one to each side of the piston. Two of these ports are drilled from the bases of annular grooves round the sleeve, and three rectangular-section Teflon rings act as seals to prevent the leakage of fluid between the grooves; the third, which is the outlet port to the adjacent end of the servo cylinder, breaks out on the periphery of the sleeve, near its inner end.

Although a three-way, open-centre type valve spool is employed, it is unconventional in that the valve lands are machined parallel to the axis instead of round the periphery. This construction has been adopted, of course, so that the valve can be actuated by rotation instead of by axial movement. As has already been explained, this gives much more direct and quicker actuation of the valve than was possible in the previous design and hence the response is improved.

The way in which rotation of the spool effects transfer from one port to the other is illustrated in Fig. 7. In the neutral position of the valve, oil flows in from the connection from the pump, through the central port in the sleeve, into the two grooves in the spool, and thence is returned through the two outlet ports in the sleeve. When a torque is applied to the steering column, to turn the vehicle to the right, the valve is rotated clockwise. In these circumstances, the flow goes through the inlet port in the sleeve, into the left-hand groove, whence it is transferred through drilled ducts to the far end of the servo cylinder. Oil displaced from the near end of the cylinder goes through a duct into an annular chamber around the inner end of the valve sleeve. From this chamber it passes through the hole drilled inwardly from the periphery of this end of the sleeve, and then through grooves, on the periphery of the spool and in the bore of the sleeve, whence it goes through a radial hole into the bore of the spool and finally along to its outer end. From this end, the oil passes through the thrust bearing and out to the return connection in the housing.

If the valve is rotated in the opposite direction, oil goes into the right-hand groove in the spool, through the hole drilled near the inner end of the sleeve, into the annular chamber and thence to the adjacent end of the servo cylinder. Oil returning from the other end passes through

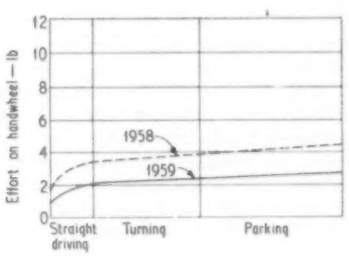
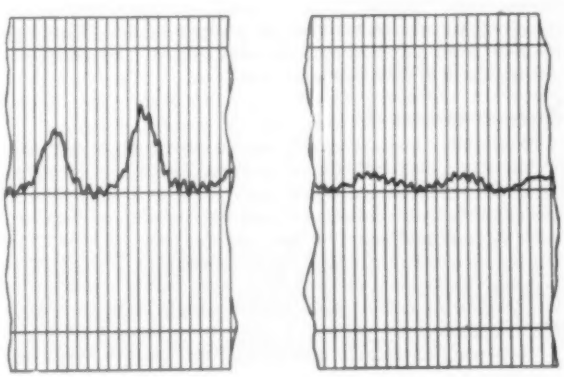


Fig. 9. In this diagram the feel of the new system is compared with that of the previous year's model

Fig. 8. The two diagrams below give an indication of the reduction in the feed-back of road shock, through the steering gear, obtained by modifications to the valve port configuration and the incorporation of a poppet valve to lock the system momentarily during severe feed-back: the diagram on the left is of the shocks recorded before and that on the right is of those recorded after the modifications were incorporated



ducts and the radial hole in the sleeve, into the left-hand groove in the spool. It then flows through the groove in the bore of the sleeve, into a radial hole and to the bore of the spool, along to the outer end and out through the thrust bearing and the return port. Although, for the sake of simplicity, only one set of ports is shown in the illustration, there are, in fact, four sets.

Development

Much detail development has been done on the valve by General Motors. One of the greatest problems was the absorption of the road shocks transmitted back from the unsprung mass of the front wheels. With the earlier, slow-acting valve, which was damped by a relatively high friction, this problem was not so difficult to solve, but the new valve with its instantaneous response and negligible internal friction, called for more positive measures to correct this condition without interfering with the delicacy of steering control. The problem was solved by modifications to the valve port configuration, and the incorporation of a poppet valve to lock the hydraulic system momentarily during severe feedback. An indication of the improvement thus obtained is given in Fig. 8.

In Fig. 9, there is a comparison between the feel of the new system and that of the 1958 power steering gear. The values plotted along the horizontal scale have been obtained by the correlation of laboratory and road tests on a large number of vehicles. With the older system, a force of 2 to 3½ lb was required for small deviations from straight-ahead driving, 3½ to 4 lb for normal turning and 4 to 4½ lb for parking. The new system requires 1 to 2 lb for small deviations, 2 to 2⅜ lb for normal handling, and only 2½ lb for parking. Other advantages claimed are that wander from the straight-ahead position has been virtually eliminated, self-centring has been improved, and the precision of the unit gives the driver a sense of complete security.

Some Recent M.E.R.L. Reports

EARLIER research summaries of the Mechanical Engineering Research Laboratory were reviewed in the January and April 1959 issues of *Automobile Engineer*. Some more have recently been issued and are dealt with below. Copies of the reports can be obtained from the Laboratory, East Kilbride, Glasgow.

Efficiency of mechanical transmissions

A range of precision dynamometers is being developed at the Laboratory, for the accurate measurement of power losses in transmission units. The largest so far available has a maximum input of 75 h.p. at 2,000 r.p.m., and it can be used for testing units having speed ratios of up to 4 : 1. An accuracy of measurement of about ±0·1 per cent is obtainable.

The equipment consists of an electric motor, mounted on low-friction trunnion bearings, and an eddy-current, swinging-frame dynamometer to absorb the power. Hydrostatic oil bearings are used to carry the dynamometer unit. The torque reactions of the motor and dynamometer are converted into hydraulic pressures, which are applied to opposite sides of a differential weigh-beam. This weigh-beam is kept continuously in balance, and the position of the movable weight provides a direct measure of the power loss in the transmission under test.

Although the dynamometers have been designed primarily for research purposes, the Laboratory is prepared to test gearboxes and other mechanical transmissions for manufacturing and other firms. The charge for this service is based on the time taken by the tests. Further details of the dynamometer design are given in a paper entitled "Development of a 75 h.p. dynamometer equipment," by H. A. G. Fletcher and J. Bamborough.

Noise measurement

Noise reduction in all machinery is important, particularly in machine tools for export to countries whose laws lay down maximum permissible noise levels. Little information is available about the noise produced by everyday mechanisms such as gears and ball bearings, and the way it is related to the dimensional accuracy of the components. This problem is being investigated at the Laboratory, to find out whether it is possible to produce quiet mechanisms more economically than at present.

Measuring equipment and special test facilities have been provided for these researches. The Laboratory is also willing to use these facilities to advise firms on the reduction of mechanical noise in their products or works. For measuring noise on site, a mobile laboratory is used, but an anechoic chamber is available at East Kilbride for measuring noise from office machinery and other relatively quiet equipment, or for measuring the directional properties of noise from machines. The Laboratory is also willing to advise firms on inspection techniques for the control of noise.

Facilities are available for calibrating microphones and associated noise measuring equipment over a frequency range from 30 to 8,000 c/s. Vibration transducers can be calibrated up to 5,000 c/s. A fee is charged for advisory work if measurements are necessary.

Cold extrusion

Maximum extrusion pressures can be greatly reduced by pre-forming a cone on the head of the billet. With a 60 deg cone angle on the billet and a 60 deg conical die entry, the pressure needed to extrude copper rod is 28 per cent less than that required to extrude a normal cylindrical billet through the same die. It is likely that this technique will be particularly useful in the production of extruded products that are normally outside the capacity of a press.

This is one of the conclusions from the first stage of an investigation of the cold extrusion of steels and non-ferrous metals under impact conditions. Work is being carried out to see in what ways the varying ram speed of a crank press affects the extruded product in comparison with extrusions from a hydraulic press, where the ram speed is constant throughout its stroke.

Pressures required to produce a given reduction in aluminium, copper and brass in a crank press were found to be similar to those needed in a hydraulic press at slower speeds. The extrusion pressure was related linearly to the logarithm of the extrusion ratio—the ratio of the cross-sectional area of the billet to that of the product—for aluminium, copper, brass, niobium, titanium, and a range of steels. Successful extrusions were carried out at large reductions from unheated billets—in most cases the limit of reduction seems to be imposed by the maximum permissible stress in the punch. Further information is given in *MERL Plasticity Report No.* 138, "Cold extrusion of metals; Part 6—Under Impact Conditions," which has been written by the two authors, M. T. Watkins and J. McKenzie.

Solution of Supercharged Engine Cycles

A Simplified Approach Involving the Application of Thermodynamic Charts

S. E. Bonamy, B.E., M.Sc., A.M.I.Mech.E., A.M.I.E.(Aust.)*

INTERNAL combustion engine charts that take into account factors such as variable specific heats, chemical dissociation, residual gases from the previous cycle and fuel-air ratios have for many years been used for the solution of internal combustion engine cycles. A classic example of such charts, at first introduced by Hershey, Eberhardt and Hottel[1], and later expanded and reproduced for the National Advisory Committee for Aeronautics, are those prepared by Hottel, Williams and Satterfield[2]. In Part I of the latter publication, a detailed analysis of the charts together with worked examples for the throttled, unthrottled and supercharged Otto cycle engines are given. Included in the charts of Part II are:

(a) *Modified Air Chart.* This is essentially an internal-energy/entropy chart for air, modified to give thermodynamic properties not only of air but also of fuel-air mixtures for a wide range of mixture strengths and containing various quantities of residual gases. The chart is plotted on a basis of one pound-mol of mixture and is ideally suited for examining isentropic processes at temperatures below which the effects of chemical dissociation are considered negligible, that is, 2,520 deg R.

(b) *Burned Mixture Charts.* These charts, plotted for various fuel-air ratios, are internal-energy/entropy charts plotted on the basis of one pound of air plus the appropriate weight of fuel, giving thermodynamic properties of burned mixtures up to 5,500 deg R.

Unfortunately, the solution of cycles with the aid of the charts involves much trial and error. The process is generally as follows: assumed values are taken for the temperature at a particular point in the cycle and for the weight fraction of residual gas, from the previous cycle, in the mixture at the beginning of compression; then the complete cycle is checked to verify the assumed values, and the appropriate adjustments are made and the cycle checked again, and so on until the correct values are obtained.

In the case of the supercharged engine the method becomes extremely laborious and it might take an inexperienced investigator as long as twelve hours to solve one cycle. A brief description of the method[2], using the same symbols and figure numbering, is as follows.

The sensible† enthalpy $H_{s_{fr}}$ per mol‡ of fresh charge entering the engine, is found by computing the work done by the supercharger, allowance being made for its efficiency and the mixing of air with fuel after compression in the supercharger.

Referring to Fig. 1, the residual gas temperature T_6 is assumed and the corresponding sensible internal energy E_{s6} and volume V_6 per mol are read from the Modified Air Chart. Step 6—6′ is considered as a constant volume mixing process of one mol of residual gas with z mols of fresh charge, so that the sensible internal energy per mol of resultant mixture at 6′ is given by:

$$E_{s6'} = \frac{zH_{s_{fr}} + E_{s6}}{z+1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Also, the volume per mol of mixture is given by:

$$V_{6'} = \frac{V_6}{z+1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

and the weight fraction of residual gas in the equivalent burned mixture at 6′ by:

$$f' = \frac{1}{1+Cz} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where C is a factor allowing for molecular contraction due to combustion, which can be determined from Fig. 6 of the Modified Air Chart.

A trial and error process is used to find a value of z that gives agreement between the values of $E_{s6'}$ and $V_{s6'}$, as calculated from equations (1) and (2) and those read from the Modified Air Chart for the appropriate f', equation (3). The corresponding sensible enthalpy H_{s6}, is read from the chart and the sensible enthalpy, H_{s1}, per mol of mixture, at the beginning of compression, is calculated by considering the mixing at constant pressure, during step 6′ to 1, of z_1 mols of fresh charge with $(1+z)$ mols of mixture at condition 6′. Hence $(1+z+z_1)H_{s1} = (1+z)H_{s6'} + z_1 H_{s_{fr}}$ .....(4)

Also, the volume V_1, per mol, and the weight fraction of residual gas f at 1, are obtained from:

$$V_1 = \frac{rV_6}{1+z+z_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

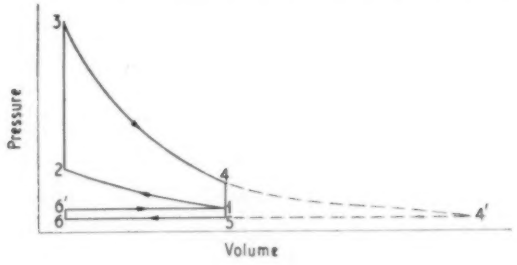
where r = compression ratio,

$$\text{and } f = \frac{1}{1+C(z+z_1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

A further trial and error process, involving a selection of z_1 to satisfy H_{s1} and V_1 from equations (4) and (5) and values read from the Modified Air Chart for the appropriate f, reveals thermodynamic properties at the beginning of compression. An isentropic compression to volume, $V_2 = V_1/r$ on the chart, making allowances for the various mixture correction factors, reveals the properties at point 2.

The internal energy e_3, per pound of air constituents, is found by adding the energy of combustion to the sensible energy E_{s2}, allowance being made for chart conversion factor, y‖. Since volume v_3, that is, $V_2 y_2$ per pound of air constituents, and e_3 are known, point 3 can be located on the

Fig. 1. The ideal P-V diagram for the supercharged Otto cycle engine



* Senior Lecturer in Mechanical Engineering, University of N.S.W.

† By sensible it is meant that the chemical portion of the thermodynamic function is excluded.

‡ Upper and lower case letters apply to the Modified Air Chart and Burned Mixture Charts respectively.

‖ Conversion factors, y, are necessary since the Modified Air Chart and Burned Mixture Charts are plotted on a different basis.

appropriate Burned Mixture Chart. Isentropic expansion to v_4, that is, v_3r, gives the properties at point 4.

It is assumed that the gas remaining in the cylinder, after process 4-5, has expanded isentropically within the cylinder to exhaust pressure, expelling part of the exhaust gas in the process. Temperature $T_{4'}=T_5$ is found from the chart and, since the exhaust process 5-6 is considered to be at constant pressure and under adiabatic conditions, temperature $T_5=T_6$. Since $v_4/v_{4'}$ gives the fraction of burned mixture remaining in the cylinder at 5, the fraction f of residual gas is $v_4/rv_{4'}$.

The temperature T_6, initially assumed, and the value of f from equation (6) are now checked relative to the values thus obtained and if found unsatisfactory, the complete process is repeated.

Alternative method

A simplified, yet very accurate, method is as follows. Refer to Fig. 1; the initial assumptions made are the temperature T_1, and the weight fraction f of residual gas in the equivalent burned mixture at the beginning of

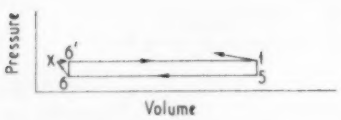


Fig. 2. The alternative cylinder charging process

compression. Thermodynamic properties at points 2, 3, 4 and 4′ are then obtained from the Modified Air and Burned Mixture Charts in the usual manner. An immediate check of $f=V_4/rV_{4'}$ is then possible, before proceeding with the remainder of the cycle.

The residual gas at 6 is assumed compressed isentropically within the cylinder to condition X, Fig. 2, by the incoming charge, a volume $V_{6'}-V_X$ being required for the process. Since the properties per pound of air constituents at 6 are considered as being the same as at 4′, Fig. 1, the properties at X can be found from the Burned Mixture Chart.

An additional volume $V_1-V_{6'}$ is taken into the cylinder during the charging stroke, making the total volume of fresh charge per cycle, V_1-V_X. Considering X to 1 a constant pressure adiabatic mixing process, the sensible enthalpy h_{s1}, per pound of air constituents is calculated from:

$$h_{s1}=fh_{sX}+(1-f)y_{fr}H_{s_{fr}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

where

h_{sX} = sensible enthalpy of residual gas at X, per pound of air constituents.

$H_{s_{fr}}$ = sensible enthalpy of fresh charge per mol.

y_{fr} = fresh charge conversion factor, mols per pound of air constituents.

Also, the sensible enthalpy per mol of mixture at 1

$$H_{s1}=\frac{h_{s1}}{y_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

where y_1 = conversion factor for mixture at 1, mols per pound of air constituents.

Temperature T_1, corresponding to H_{s1} on the Modified Air Chart can now be read and checked with the assumed value. The cycle calculations are then repeated, using the new value of T_1 until the desired accuracy is attained. In order to calculate the work done by the supercharger per cycle, the mols of fresh charge added per mol of residual gas can be found from:

$$\text{mols of fresh charge}=\frac{1-f}{f}\times\frac{1}{C} \quad \ldots\ldots\ldots\ldots\ldots\ldots(9)$$

It has been found, in solving a number of cycles by the two methods described, that the second offers a saving in time of up to fifty per cent. This saving is realized, because the method eliminates the tedious trial and error process of finding the mols of fresh charge entering the cylinder during both the constant volume and constant pressure mixing processes. Also a check can be made of the weight fraction f of residual gas early in the computations. An example of the use of the latter method is now given.

Example. A supercharged Otto cycle engine with a compression ratio of 6·5 : 1 operates in air at a pressure of 12 lb/in² abs. and temperature of 40 deg F. It is supercharged to a pressure of 30 lb/in² abs., and after the supercharging, sufficient liquid fuel at 70 deg F is added to give a chemically correct air-fuel ratio. The efficiency of the supercharger is assumed to be 70 per cent.

It is required to compute the thermodynamic properties at the various points in the cycle and calculate the thermal efficiency.

Enthalpy of air at 12 lb/in² abs., 500 deg R
= 980 B.Th.U/mol, from the Mod. Air Chart

Enthalpy of air after isentropic compression to 30 lb/in² abs.
= 2,025 B.Th.U/mol, from the Mod. Air Chart

∴ Work done on air by supercharger
$$=\frac{2{,}025-980}{0\cdot70}$$
= 1,493 B.Th.U/mol

Enthalpy of air entering manifold
= 980 + 1,493
= 2,473 B.Th.U/mol

Mols of liquid fuel injected per mol of air
= 0·01749

Sensible enthalpy of liquid fuel at 530 deg R
= −12,600 B.Th.U/mol, from Fig. 9 of Mod. Air Chart

Enthalpy of fresh charge entering engine
$$=\frac{2{,}473+0\cdot01749\times(-12{,}600)}{1\cdot01749}=2{,}229 \text{ B.Th.U/mol}$$

In this instance, pressure correction factors for enthalpy are negligible. Assume $T_1=700$ deg R and $f=0\cdot0200$, then the values at various points of the cycle are given in the accompanying Table. From this it follows that:

$$f=\frac{8\cdot81}{71\cdot0\times6\cdot5}=0\cdot0191$$

This corrected value of f is considered satisfactory. It would make negligible change in values at 1, 2, 3, 4, and 4′ if that portion of the cycle were to be repeated.

$$h_{s1}=(0\cdot0191\times68\cdot7)+(0\cdot03515\times0\cdot9809\times2{,}229)$$
= 89·97 B.Th.U/lb air constituents

Point	1	2	3	4	4′	6	X
T, deg R	700	1,285	5,225	3,710	2,160	2,160	2,605
P, lb/in² abs	30	365	1,565	170	12	12	30
V, ft³/mol	250	38·5					
v, ft³/lb air constituents			1·36	8·81	71·0	71·0	34·8
E_t, B.Th.U/mol	1,155	4,760					
e, B.Th.U/lb air constituents			1,428	813	368	368	494
S, B.Th.U/mol, deg R	3·52	3·52					
s, B.Th.U/lb air constituents, deg R			0·4615	0·4615	0·4615	0·4615	0·4615
Chart	Mod. Air		Burned Mixture				

$$H_{s1} = \frac{89{\cdot}97}{0{\cdot}0352} = 2{,}556 \text{ B.Th.U/mol}$$

The corresponding value of T_1, from the Burned Mixture Chart, is 702 deg R, which checks satisfactorily with the assumed value. Mols of fresh charge added per mol of residual gas

$$= \frac{0{\cdot}9809 \times 1}{0{\cdot}0191 \times 1{\cdot}05} = 48{\cdot}91$$

Total mols of mixture = 49·91

Mols of air entering supercharger, per mol of residual gas:

$$= \frac{\text{Mols of fresh charge}}{y_{fr} \times \text{molec. wt. of air}}$$

$$= \frac{48{\cdot}91}{0{\cdot}03515 \times 28{\cdot}95} = 48{\cdot}06$$

Work done per mol of residual gas during processes 1, 2, 3, 4:

$$= \text{Mols of mixture } \left[\frac{(e_3 - e_4)}{y_1} - (E_{s2} - E_{s1})\right]$$

$$= 49{\cdot}91\left[\frac{1{,}428 - 813}{0{\cdot}0352} - (4{,}760 - 1{,}155)\right] = 692{,}000 \text{ B.Th.U.}$$

Work of pumping-loop per mol of residual gas:

$$= (P_1 - P_6)\,(V_1 - V_2)\,\frac{144}{778} \times \text{mols of mixture}$$

$$= (30 - 12)\,(250 - 38{\cdot}5)\,\frac{144}{778} \times 49{\cdot}91 = 35{,}170 \text{ B.Th.U.}$$

Work done on supercharger, per mol of residual gas:

$= 48{\cdot}06 \times 1{,}493 = 71{,}750$ B.Th.U.

Net work of cycle per mol of residual gas:

$= 692{,}000 + 35{,}170 - 71{,}750 = 655{,}420$ B.Th.U.

Mols of fuel added per mol of residual gas:

$= 48{\cdot}06 \times 0{\cdot}01749 = 0{\cdot}8406$

Heat available in fuel added:

= mols of fuel × molec. wt. × calorific value per pound

$= 0{\cdot}8406 \times 112{\cdot}13 \times 19{,}040 = 1{,}794{,}600$ B.Th.U.

$$\text{Thermal efficiency} = \frac{655{,}420}{1{,}794{,}600} = 36{\cdot}5 \text{ per cent.}$$

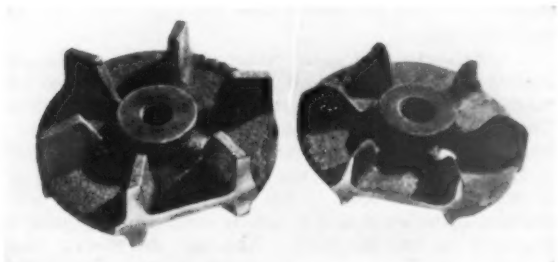
References

1. HERSHEY, R. L., EBERHARDT, J. E., and HOTTEL, H. C.: "Thermodynamic Properties of the Working Fluid in Internal Combustion Engines", *S.A.E. Journal*, Oct., 1936.
2. HOTTEL, H. C., WILLIAMS, G. C., and SATTERFIELD, C. N.: "Thermodynamic Charts for Combustion Processes", Parts 1 and 2, *John Wiley*, New York, 1949.

Anti-Freeze

INTRODUCED this year is a New Bluecol anti-freeze mixture, to a completely new formulation that ensures protection against both frost damage and corrosion damage in petrol and diesel engines. It is claimed to be the first anti-freeze to give this complete protection, and is also said to be the first to be offered for sale with a binding written guarantee.

The problem with an ethylene-glycol based anti-freeze has always been to find an inhibitor or combination of inhibitors that will protect, from attack by corrosion, all the metals in an engine cooling system under all operating conditions. Such attack will, in time, if unchecked, reduce



Above is an illustration of two water pump impellers that have each been given a 700 hour test, that on the left in a 25 per cent solution of New Bluecol, and the other in a mixture to DTD 779 specification

or even stop the circulation of coolant, and lead to overheating and boiling.

Shown in the accompanying illustration are two water pump impellers. One edge of each impeller has been ground down so that the cross sections of the two components can be seen more easily. When new, both were identical, but after a 700-hour test in a rig simulating the cooling system of a vehicle, they were markedly different: that on the left, which was run in a coolant containing 25 per cent by volume of New Bluecol, was relatively unharmed, while that on the right, which was tested in precisely the same conditions in a coolant containing 25 per cent of an anti-freeze mixture made to the DTD 779 specification, was seriously eaten away by corrosion. Obviously, the efficiency of the right-hand impeller has been considerably impaired by the corrosion.

With regard to inhibitors in general, there are two main types: those that, as a result of chemical change, form a protective layer over metals liable to be subject to rust formation and to attack by organic acids; and, secondly, those that are alkaline, and therefore mop up acids. In New Bluecol, two of the first type are used, plus one of the second. The two inhibitors of the first type are most effective in the stable conditions that are guaranteed by that of the second type, and it is stated that they give complete protection to all the metals to be found in cooling systems employed for the power units of road vehicles.

Ceramics Accelerometer

FOR measuring vibration and shock, Technical Ceramics Ltd., Wood Burcote Way, Towcester, Northants., have introduced a high-sensitivity transducer unit weighing only 20 gm. This unit is designated Type G88. In it is used the firm's piezo-electric ceramic material TCL3, which has a wide temperature range and low temperature coefficient, and remains stable over long periods. The transducer has a linear output over the acceleration range 0·01g to 250g, and is calibrated from 29 to 800 c/s. It has a low transverse sensitivity in any direction and, because of its high capacitance, the use of a cable longer than the 3 ft supplied does not markedly reduce its sensitivity. The sealed construction of the G88 unit enables it to be operated in conditions of even the highest relative humidity.

Russian Translation

THE Production Engineering Research Association has recently published the fourth issue of *Machines and Tooling*, a full English translation of the similarly numbered issue of the Russian technical periodical *Stanki i Instrument*. This translation contains a number of interesting articles on machine tools and machine shop methods, and copies may be obtained from the Association, at Melton Mowbray, Leics.

ROTARY EXHAUSTERS

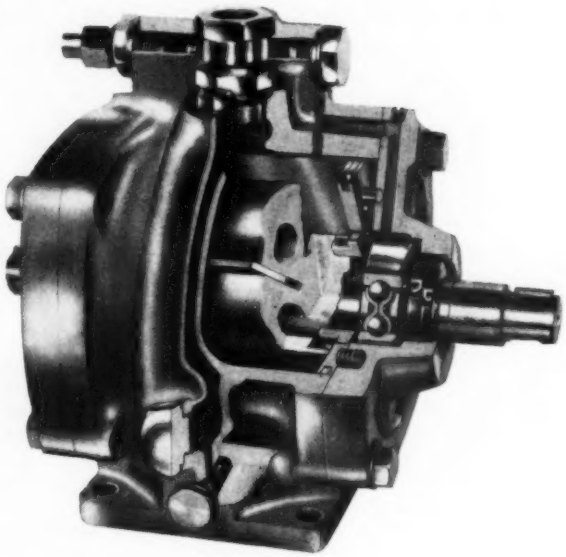
Some Notes on the Development and Construction of Clayton Dewandre Vacuum Brake Equipment

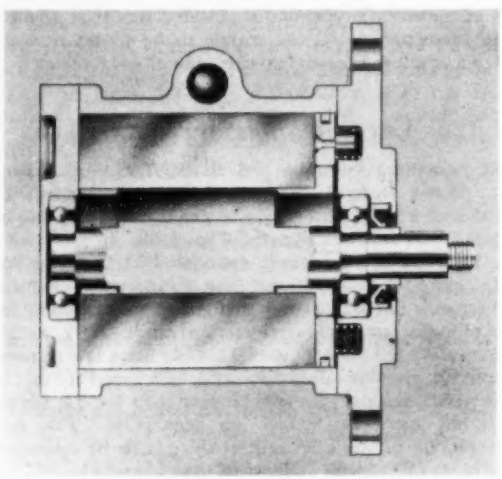
VACUUM operated systems of road vehicle braking have been in extensive use since 1925. The early installations were, of course, confined to petrol engined vehicles; and one of their chief advantages was simplicity, since the vacuum was obtained from the induction manifold of the engine. However, the adoption of the diesel engine made it necessary to provide an independent source of sub-atmospheric pressure. To meet this need, the Clayton Dewandre Co. Ltd., of Lincoln, designed a rotary exhauster, the basic layout of which is still found in the company's current range.

These exhausters are rotary pumps of the sliding vane type, with a six-blade rotor positioned eccentrically in the pump body. On the earlier models, the cam rings that moved the blades outward were integral with the end covers. To accommodate differential thermal expansion between the rotor and the body, the end covers housed spring-loaded sealing plates; lubrication was by wick-feed oil cups. Leather shaft seals were employed, but had the disadvantage that they became hard because of the heat generated by internal friction. This loss of resilience tended to lead to failure of the seals, thus allowing air to enter the exhauster and oil to escape. The frequent failure of operators to replenish the oil supply aggravated the situation.

The first major improvement was the introduction in 1938 of a floating cam ring, which was modified in 1943 by the incorporation of an end flange; the purpose of this flange

A base-mounted exhauster with through drive. Lightening holes are cored in the rotor which, on all current models, is of aluminium, cast on to the shaft that is carried in ball bearings lubricated through ducts





This view of one of the smaller Clayton Dewandre exhausters, the Type A.300, shows the sealing plate and ring at the right-hand end of the rotor

was to keep the ring square with the blades, thereby improving the pumping efficiency at low speeds. Another important development was the provision of a means of automatic lubrication: the oil was drawn from the engine sump or from a separate container, by means of the vacuum created in the exhauster. At about the same time, a synthetic material was adopted for the shaft seals. Since this material retained its properties at high temperatures and was resistant to hot oil, it eliminated the troubles inevitably encountered with the leather seals previously used for this particular duty.

It was found that the axial thrust of the rotor spindle was sometimes causing premature failure of the bearings, but this trouble was overcome by fitting more substantial bearings. The earlier types of sealing plate were located radially in a counterbore in the end cover, but on exhausters designed in 1946 and subsequently, the plates are located in the bore of the exhauster body. This later type was made very effective by fitting it with a radially sprung ring, housed in a groove in the periphery. Although the sealing plate located in the bore is now the standard design, the earlier layout is still found in certain exhausters that have been in production for many years.

To avoid the generation of excessive heat internally during sustained running at high depressions, snifter valves have for many years been fitted to the Clayton Dewandre exhausters. These are simple spring-loaded ball valves to admit air, as necessary, to limit the vacuum, usually to about 25 in of mercury. A relatively recent change of specification on some models has been the introduction of fibre rotor blades in place of cast iron or steel ones. Fibre blades have proved to have a lower rate of wear and are quieter in operation than the metallic type. They enable use to be made of the higher vacuum available without increase in the heat generation, and have rendered the snifter valve unnecessary in most installations. Some reduction in weight has naturally resulted from the change of blade material, but a

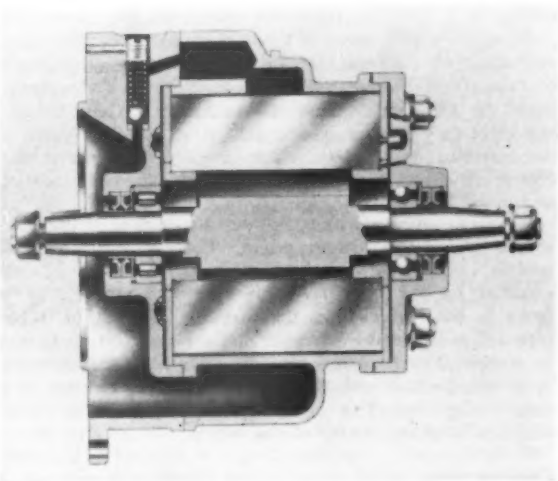
greater saving has been effected by the substitution of aluminium for cast iron as the material of the rotor. Rotors of this type, which were introduced in 1958, are die cast directly on to the steel shaft.

Current types and installations

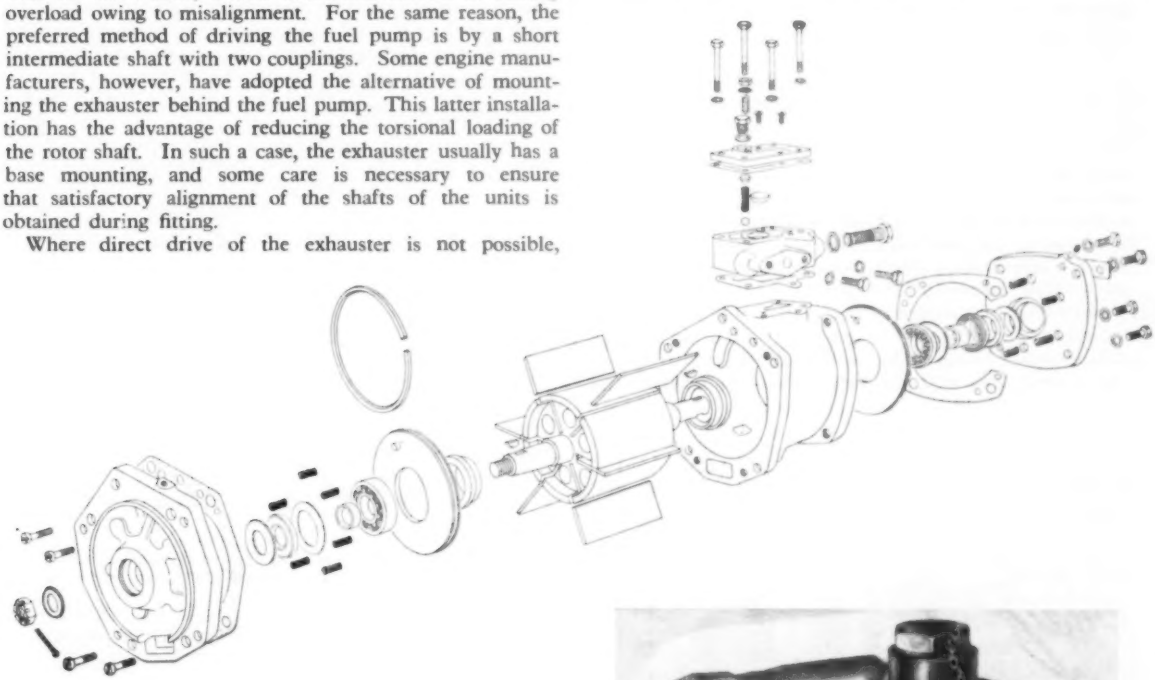
The present range of Clayton Dewandre exhausters is extensive, and each model has a designation represented by a prefix letter and a three-figure number. There are four prefix letters—A, B, C and E—and they indicate the bore diameter of the body: A=3·25 in, B=4·562 in, C=5·125 in, and E=5·375 in. The number is the length of the rotor in hundredths of an inch. Thus, an exhauster with the designation B.350 has a bore of 4·562 in and a rotor length of 3·5 in.

To cope with the wide range of possible installational requirements, four different mounting methods are available, They are spigot, base, flange and bracket mountings. Probably the most common installation is with the exhauster flange-mounted on the rear of the timing case, the unit being driven from the gear train and driving the fuel pump installed in tandem with it. With this arrangement, it is customary to locate the pump by a spigot ring concentric with the drive shaft, as this minimizes the risk of bearing overload owing to misalignment. For the same reason, the preferred method of driving the fuel pump is by a short intermediate shaft with two couplings. Some engine manufacturers, however, have adopted the alternative of mounting the exhauster behind the fuel pump. This latter installation has the advantage of reducing the torsional loading of the rotor shaft. In such a case, the exhauster usually has a base mounting, and some care is necessary to ensure that satisfactory alignment of the shafts of the units is obtained during fitting.

Where direct drive of the exhauster is not possible, because of the engine layout or lack of space, it can in some instances be mounted on the gearbox. The most satisfactory drive is then a spur gear on the input shaft of the gearbox, but an alternative is belt drive, in which instance a bracket mounting is employed. If a drive from the gearbox is impracticable, it may be possible to install a bracket-mounted unit on the chassis frame, and to drive it by



Sectional view of the Type E.425 exhauster. The two sealing plates of this unit have no spring rings and are located in the end covers of the body



Above: The various components of a typical exhauster are seen in this exploded view. Six sliding vanes are carried in slots in the rotor, the shaft of which is eccentric to the bore of the body. Bolted to the top of the unit is the valve body; this houses both the non-return and the snifter valves. Right: An alternative to the base mounting is the flange mounting, as employed on the Type E.425 exhauster. This model has through drive; a spigot ring on the flange ensures correct shaft alignment on bolting-up to the engine, and hence minimum loading of the bearings

means of a vee-belt, from the pulley on the crankshaft.

Where a snifter valve is fitted it should preferably pass only clean air into the exhauster. Provision is often made for the air to be drawn through ducting from the crankcase. In the relatively dust-free conditions of Great Britain, the valve may be connected instead to an external source of air, provided that a clean region is selected for the intake. However, it is preferable, and in dustier climates essential, to connect the valve to an air filter.

Another important aspect is the installation of the non-return valve in the vacuum system. There are three possible positions of this valve, and the choice is largely one of convenience for the particular application. The valve may be fitted to the end plate of the vacuum reservoir, or in the pipe line between the exhauster and the reservoir, or it may be embodied in the exhauster. With the latter arrangement, it is incorporated with the oil filter and snifter valve in a single assembly. This assembly is called the valve body, and it is bolted to the top of the casing.

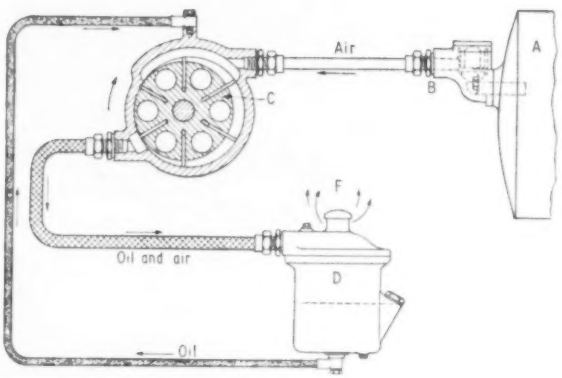
Construction

The components of a typical exhauster are shown in an accompanying illustration. Normally, the body of the exhauster is of cast iron, but some models have an aluminium body, die cast round a cast iron sleeve. Cast iron is also normally used for the end covers but here, too, aluminium may be employed; in this case, the covers are die cast on to steel sleeves which form the bearing housings. As was mentioned previously, rotors currently in production are of aluminium and are cast on to the shaft. Ball or roller bearings carry the shaft and rotor assembly eccentrically in the body. The shaft may terminate within the end cover or it may be extended through it; keyways are provided in the shaft ends, which may be tapered or parallel, threaded or cotter grooved, to suit installation requirements. Except in the case of blind end covers, a synthetic rubber seal is fitted outboard of the bearing; it is normally of the double lipped type so that it prevents not only the entry of air but also the leakage of oil caused by the initial pressure in the exhauster body under starting conditions.

As already indicated, the rotor blades may be of steel, cast iron or fibre. With aluminium rotors, however, it is essential that only fibre blades are used. Any of the three blade materials is satisfactory in conjunction with a cast iron rotor, but all the blades of a set must be of the same material. Steel or cast iron blades may be replaced by fibre blades, if desired. Where fibre blades are fitted initially, this is shown by the addition of the figure 1,000 to the designation number. A ring of axially disposed springs, housed in pockets in the end covers, holds each sealing plate in light contact with the end of the rotor. Rotation of the sealing plate is prevented by a dowel peg on the plate; this peg registers in one of the spring pockets.

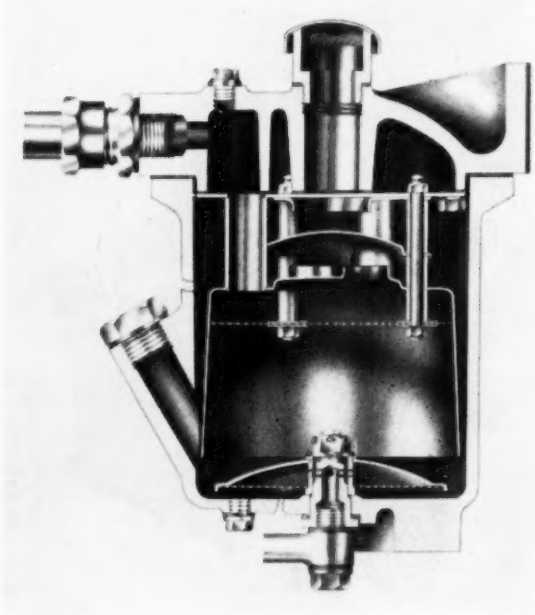
The end flanges of the cam rings are located radially in the sealing plate bores to ensure that the guiding portions of the rings are coaxial with the bore of the exhauster body. These guiding portions register in counterbores in the ends of the rotor. Their purpose is to keep the rotor blades in contact with the bore at low speeds, particularly when the oil is cold. At higher speeds, of course, centrifugal force is sufficient to maintain the contact.

Usually, the inlet and outlet ports are at the top and bottom of the exhauster body respectively, but, to suit individual installations, they may be at the sides. Where the snifter and non-return valves are embodied with the oil filter and vacuum connections, they are contained in the valve body on top of the exhauster, as was mentioned earlier. From the valve housing, a pipe leads to the chassis-mounted vacuum reservoir. Two types of non-return valve, both of which are illustrated, may be used with this arrangement: one is of metal, with a rubber seating face, and the other, the latest type, is a rubber hemisphere.



A *vacuum reservoir;* **B** *non-return valve;* **C** *exhauster;* **D** *oil reservoir and filter;* **F** *breather for released air*

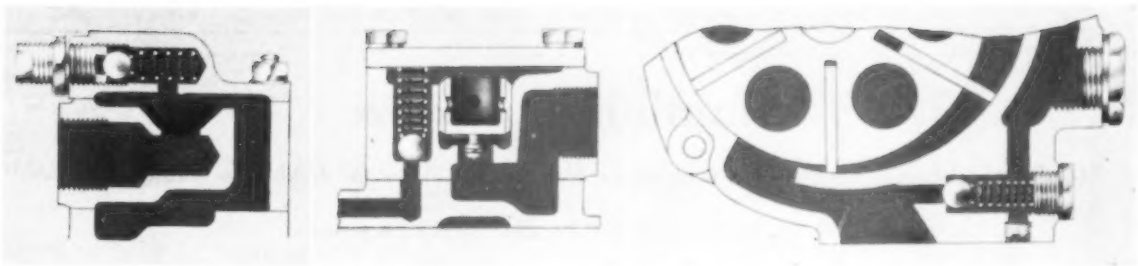
Above: Diagrammatic layout of an installation employing a combined oil reservoir and separator. Alternatively, the engine oil supply can be used



Left: The combined reservoir and separator unit. Oil is taken from the base and is returned to the top; a system of strainers separates the air

Lubrication

The functions of the lubrication system are to deliver an adequate supply of oil to the bearings and moving parts, and to provide a seal between the blades and the bore of the exhauster. Where the exhauster is mounted on the power unit, it is now becoming common practice to lubricate it with oil from the engine sump, because of the simplicity and cheapness of this arrangement. If this is not possible, or if the exhauster is not mounted on the engine, a self-contained oil reservoir and separator unit is used. The oil supply is led to the inlet connection on the exhauster, whence it goes through ducts to the end cover; the depression in the body



Three typical valve arrangements. Left: An adjustable snifter valve and a rubber hemispherical non-return valve. Centre: A snifter valve incorporated with a piston type, rubber-faced non-return valve. Right: A separate type of snifter valve mounted at the bottom of the exhauster body

draws in the oil, which is distributed to all the interior surfaces and bearings. Finally, the lubricant, together with the air evacuated from the reservoir, is ejected through the outlet port.

If the engine oil supply is used, the discharged oil and air are led directly into the crankcase. It follows that adequate ventilation of the crankcase is necessary to avoid the build-up of back pressure and consequent reduction of efficiency of the exhauster. Where the oil reservoir and separator unit is employed, the oil feed is drawn from its base, and the ejected air and oil are returned to the top. The oil is separated from the air by a system of strainers. In the body of the unit is a combined level and filling orifice. The location of the oil separator is determined by the fact that the oil level should not be higher than the axis of the rotor; otherwise there will be a gravity induced flow of oil to the exhauster. Also, to avoid excessive suction lift, the unit should not be more than 12 in lower than the axis of the rotor. The oil level has to be checked regularly and the lubricant in the reservoir changed every 5,000 miles.

Induction Heating

IT HAS been announced by Pye Ltd. that the company is organizing a course for users and potential users of induction heating. The course will begin at 2 p.m. on the 1st December 1959, and will finish at 6 p.m. on the following day. It will cover the theory of induction heating, the operation of the generator, and the design of coils for a wide variety of applications. No charge will be made for the course, but members will be required to pay for their accommodation, which can be arranged by the company. Further details may be obtained from Mrs. E. Raeburn, Pye Process Heating, 28, James Street, Cambridge, to whom applications should be made by those wishing to attend the course.

Test Equipment

TWO additions have been announced to the Nashton range of small-size electronic test equipment. The first is the Flash Tester, for insulation testing to B.S. 816-1952. It provides a 50 c/sec A.C. test voltage variable from 500 to 2,000 volts in sixteen 100 volt steps. The variation is effected by means of a rotary switch connected to the primary winding of the transformer, the secondary winding of which provides the test voltage. A two-position switch enables both the applied voltage and the associated leakage current to be indicated on the same moving-coil meter. The probe tip is shielded by a retractable, spring-loaded sleeve. An input of 200 to 250 volts A.C., on 40 to 60 c/sec, is required for the Flash Tester, which has a consumption of 4 VA. The instrument weighs 6 lb, complete with a case measuring $8\frac{1}{2} \times 6 \times 6$ in.

An ohmmeter is the second new item of equipment. It will measure resistances between 10 and 10,000 ohms, in eight ranges, to an accuracy of ± 3 per cent of the reading. To enable the resistance value to be read in the centre portion of the scale, where the accuracy is greatest, the ohm ranges each cover two decades although they are switched in one-decade steps; the megohm ranges cover one decade, again with one-decade steps. The ohmmeter embodies a Weston moving-coil meter, with a knife-edge pointer and mirror scale. It measures $8\frac{1}{2} \times 5 \times 5$ in, and is designed for operation on a 40 to 60 c/sec input of 205 to 245 volts, with a consumption of 16 VA. The manufacturers of Nashton electronic test equipment, from whom further particulars may be obtained on request, are Nash and Thompson Ltd., Chessington, Surrey.

Electronic Batch Counter

THE Elcontrol Dekatron Batch Counter BC1 is already in extensive use for high-speed counting work. For applications where the required speed of counting does not exceed 600 items per minute, an additional instrument, known as the Electronic Batch Counter BC2 has been introduced by Elcontrol Ltd. The BC1 can be operated from either a photo-electric input or from an electrical input through mechanically operated contacts. It is a self-contained unit housed in a steel case measuring $7\frac{1}{2} \times 5\frac{3}{4} \times 5$ in. Further details are obtainable from the manufacturers of the batch counter, whose address is Wilbury Way, Hitchin, Herts.

Dexion Accessories

SOME extra accessories, for use with the familiar Dexion slotted angle material, have been added to the firm's range of products. One of them is a T-section foot that fits the type 140 angle, measuring $1\frac{3}{8} \times 1\frac{3}{8}$ in. This foot is made of tough, grey plastics, and it not only protects the floor surface but also provides non-slip contact. The second accessory is a 4 in rubber castor, which is superior to the existing $2\frac{1}{2}$ in unit for the handling of heavy loads, particularly on uneven surfaces. Either the fixed or the swivelling type is available, and both can carry a load of up to 200 lb. The makers are Dexion Ltd., Maygrove Road, London, N.W.6.

Aluminium Bronze

Metallurgical Considerations Relating to the Use of This Alloy for High Temperature Service

G. FitzGerald-Lee, F.R.Econ.S., M.I.E.E., A.R.Ae.S.

ALUMINIUM bronzes retain a high proportion of their strength at elevated temperatures, a fact which, coupled with their resistance to oxidation and to corrosion, makes them the best copper-based alloys for many applications in steam plant, internal combustion engines and chemical engineering applications involving moderately elevated temperatures. Although no copper-based alloy can be expected to possess the strength of the special heat-resisting steels, and alloys rich in nickel and chromium, at temperatures above a red heat, the aluminium bronzes are amongst the most suitable metals for use up to at least 400 deg C, the highest temperature likely to be encountered in many types of installation.

Examples of the use of aluminium bronzes on account of their resistance to oxidation at high temperatures are valve seats and guides for internal combustion engines, and in certain cases cylinder heads. Valve seats for both inlet and exhaust systems are machined from forged and extruded alloys of various compositions, as also are valve guides. Wrought aluminium bronzes are used for gland rings and exhaust manifold nuts because they show little tendency to seize on to steel screw threads after service at the temperatures involved.

Cast aluminium bronzes are used for cylinder heads and insert pieces for light alloy cylinder heads; they have given good service with special types of engines for motor cycles, cars and speed-boats. The good heat-conducting properties of the aluminium bronze components, coupled with their resistance to oxidation, are mainly responsible for their high performance. Some sparking plug body parts are also made of aluminium bronze, since the metal resists the action of heat and allows the plugs to operate at relatively low temperatures; such sparking plugs are used on many racing machines.

The jaws or clamps of electrical resistance welding machines are further instances of the use of aluminium bronze; appreciable hardness is required in such parts in order to withstand welding pressures at the high temperatures at which they may operate, while a further requirement is good electrical conductivity. Terminal connections of electric furnaces and other plant are often made of this alloy, especially when high temperatures are encountered in service. Other related applications are searchlight components and gas stove grilling plates. The fact that aluminium bronze does not form a heavy oxide coating which can flake off is particularly important in such applications.

In the heat treatment of duplex aluminium bronzes, the $\alpha+\beta$ type of structure is better than that in which the β has been converted into $\alpha+\gamma 2$, because the presence of $\gamma 2$ tends towards brittleness, especially if the texture of the structure is coarse. The accompanying equilibrium diagram, however, shows that α and $\gamma 2$, not α and β, are the stable phases under service conditions at temperatures up to the eutectoid horizontal at 565 deg C.

When used for prolonged periods at such temperatures, any β which may have been present originally will gradually change into $\gamma 2$, at a rate depending on the temperature. At 500 deg C the reaction is substantially complete in a few hours, while at 250 deg C it progresses very slowly and part of the β would probably remain unchanged after years of exposure.

It is thus obviously important to ascertain how far, if at all, the inevitable formation of $\gamma 2$ is detrimental for service at moderately high temperatures. Investigations into this problem covered material which was stabilized by heating for three days at 500 deg C to ensure completion of the reaction before testing was begun, as well as material in the normal, or $\gamma+\beta$, condition both before and after holding for four weeks at 250 deg C.

Much of the work on this subject was undertaken by E. Voce and A. P. C. Hallowes, on behalf of the British Non-Ferrous Metals Research Association, and by Ampco Metals, Inc., on whose behalf R. I. Jaffee and R. H. Ramsey conducted the investigations. Tables 1, 2, 5, and 6 were compiled by Voce and Table 7 in conjunction with Hallowes.

Table 1—CHANGES THAT OCCUR IN RESPECT OF MECHANICAL PROPERTIES, DUE TO DECOMPOSITION OF β INTO $(\alpha+\gamma 2)$

Particulars	*As extruded*	*a*	*Normalized and held at 250 deg C for* 1 *week*	2 *weeks*	3 *weeks*	4 *weeks*	*b*
10 *per cent aluminium bronze* Composition: 10·47 per cent Al, 0·01 per cent Fe, 85·52 per cent Cu							
Limit of proportionality, ton/in²	—	1·8	2·1	2·7	—	3·1	8·5
0·1 per cent proof stress, ton/in²	—	4·5	7·6	9·1	—	8·6	11·4
Tensile strength, ton/in²	37·1	32·8	31·7	35·3	—	32·5	27·4
Per cent elongation on $\sqrt{4}$ area	31	25	24	21	—	18	14
Young's Modulus, lb/in² × 10⁶	—	14·5	14·8	15·5	—	14·9	19·4
Vickers Diamond Pyramid hardness number	—	146	—	—	—	162	—
Structure, as seen under microscope	$\alpha+\beta+(\alpha+\gamma 2)$	$\alpha+\beta$	no change	no change	—	incipient $\beta\rightarrow(\alpha+\gamma 2)$	$\alpha+(\alpha+\gamma 2)$
10 *per cent aluminium bronze with* 3 *per cent iron* Composition: 10·13 per cent Al, 2·8 per cent Fe, 87·07 per cent Cu							
Limit of proportionality, ton/in²	—	1·8	4·9	4·9	4·5	5·3	16·5
0·1 per cent proof stress, ton/in²	—	6·0	14·4	12·8	13·3	12·8	18·8
Tensile strength, ton/in²	46·9	43·8	44·8	45·3	46·0	47·5	38·6
Per cent elongation on $\sqrt{4}$ area	17	21	18	19	18	20	14
Young's Modulus, lb/in² × 10⁶	—	16·5	18·4	17·7	18·1	17·8	19·8
Vickers Diamond Pyramid hardness number	—	161	170	178	179	189	192
Structure, as seen under microscope	$\alpha+\beta+(\alpha+\gamma 2)+$ Fe	$\alpha+\beta+$ Fe	no change	no change	incipient $\beta\rightarrow(\alpha+\gamma 2)$	incipient $\beta\rightarrow(\alpha+\gamma 2)$	$\alpha+(\alpha+\gamma 2)+$ Fe

a: Normalized 1 hour at 825 deg C and cooled in air b: Normalized and reheated for 3 days at 500 deg C, then slowly cooled during 3 days

Table 2—GENERAL COMPARISON BETWEEN TENSILE TESTS ON ALUMINIUM BRONZES AT ROOM TEMPERATURE AND AT 400 DEG C

Percentage Composition				Condition	Tests at Room Temperature			Tests at 400 deg C		
Cu	*Al*	*Fe*	*Ni*	*a*	*b*	*c*	*d*	*b*	*c*	*d*
	by difference									
97·93	2·06	0·01	—	cold drawn 50 per cent	29·0	18	72	11·9*	28*	40*
				1 hr at 575 deg C	17·3	65	82	9·1	35	54
94·33	5·66	0·008	—	cold drawn 50 per cent	46·4	20	66	9·4	33	29
				1 hr at 575 deg C	27·3	81	80	9·4	21	20
90·20	9·76	0·04	—	extruded	37·1	31	38	15·7	47	43
				normalized	34·2	32	29	13·9	44	36
				stabilized	27·4	14	11	15·3	35	34
88·89	11·10	0·006	—	extruded	39·7	9	12	12·4	104	95
				normalized	33·0	6	11	12·2	89	96
				stabilized	32·6	2	2	19·7	40	34
87·92	12·06	0·02	—	extruded	35·6	7	13	16·4	49	52
				normalized	31·1	5	11	17·3*	28*	65*
				stabilized	44·0	nil	2	22·5	21	25
87·07	10·13†	2·80	—	extruded	46·9	17	26	19·4	51	46
				normalized	42·7	26	25	16·8	77	59
				stabilized	38·6	14	28	20·3	57	59
85·97	9·96	4·07	—	hot forged	39·7	32	—	16·1	73	62
				stabilized	41·0	22	20	21·6	60	51
88·67	10·09	0·20	1·04	hot forged	52·0	10	—	20·6	48	59
				stabilized	38·4	10	10	—	—	—
87·80	9·69	1·10	1·50	hot forged	43·0	26	36	20·8	48	52
				stabilized	36·9	28	25	20·7	41	38
80·76	9·55	4·70	4·97	hot forged	52·6	16	—	24·3	37	32
				stabilized	48·3	24	33	18·2	62	67

**Results variable owing to partial annealing or change of structure during test; mean values of several tests recorded.*
†*Aluminium determined.*
(*a*) *Normalized for 1 hour at 800 deg C and quickly cooled in air. Stabilized: normalized as mentioned, reheated for 3 days at 500 deg C and slowly cooled in furnace.*
(*b*) *Tensile strength, ton/in².* (*c*) *Per cent elongation on* $\sqrt{\text{area}}$. (*d*) *Per cent reduction of area.*

Table 3 is by Jaffee and Ramsey and Table 4 is from an unpublished report by A. Thum and H. Sigwart.

Table 1 shows the progressive change in mechanical properties of 10 per cent aluminium bronzes, with and without iron, during the four week period. After the first week at 250 deg C, there was a distinct increase in the limit of proportionality, proof stress and hardness, with relatively little change in tensile strength and elongation; but even after four weeks, the properties of the fully stabilized material had not been attained.

Complete stabilization, effected by heating for three days at 500 deg C and cooling very slowly, was characterized by a further considerable increase in the elastic properties and hardness, with a slight diminution of strength and ductility. In this condition, however, elongations reached 14 per cent and the material could not be regarded as brittle. The important inference may be drawn that the presence of the supposedly brittle $\gamma 2$ phase is much less harmful to the mechanical properties than might be expected.

Table 2 shows the results of tensile tests at room temperature and at 400 deg C on ten aluminium bronzes. The first two alloys, containing respectively 2·06 per cent and 5·66 per cent aluminium, are single phase, cold working alloys; they were tested after cold drawing to 50 per cent reduction of sectional area and after annealing for one hour at 575 deg C. In each case, the tensile strength at 400 deg C, after annealing, was a little over 9 ton/in², and the extra strength imparted by the cold drawing operation was not retained under test at this temperature.

The properties of the remaining eight alloys, which contained sufficient aluminium to give the duplex type of structure, are more interesting. Each metal was tested as received, either extruded or hot forged, and also after stabilizing. The four extruded samples were also tested in the less permanent normalized condition.

No lack of strength and ductility at 400 deg C is in evidence in the results, even in the stabilized samples, in which the presence of the $\gamma 2$ phase reduces the elongation values at room temperature. For instance, the stabilized alloy containing 12·06 per cent aluminium was without ductility at room temperature, but acquired an elongation of 21 per cent when tested at 400 deg C.

It may be inferred that the slow formation of $\gamma 2$ during service at temperatures around 400 deg C, far from being detrimental, actually improves the properties at such temperatures. The importance of such a conclusion cannot be overstressed, and it is in accord with the results given in Table 3, which show a marked improvement in ductility between 300 and 400 deg C.

Table 3 includes test results at subnormal temperatures and indicates that aluminium bronzes gain rather than lose strength and ductility as well as hardness under such conditions, while impact values are scarcely, if at all, impaired. The Table also shows the fact that welds made by the carbon arc method have properties comparable with those of the parent metal, except for a general diminution of impact values at low temperatures.

Apart from the work of Voce, little information is available

The characteristic equilibrium diagram for the copper-aluminium alloys

Point	A	B	C	D	E	F	G	H	I	J	K	L
Deg C	1083	1037	1037	1037	1048	1036	1036	1036	1022	1022	1022	958
Al, per cent	0	7·5	8·5	9·5	12·4	14·95	15·25	16·0	16·9	17·1	18·0	20·0

Point	M	N	O	P	Q	R	S,S'	T	U	V	W	X
Deg C	963	963	963	873	873	780	780	565	565	565	0	0
Al, per cent	15·1	15·45	16·4	17·8	20·0	13·6	15·6	9·4	11·8	15·6	9·4	16·2

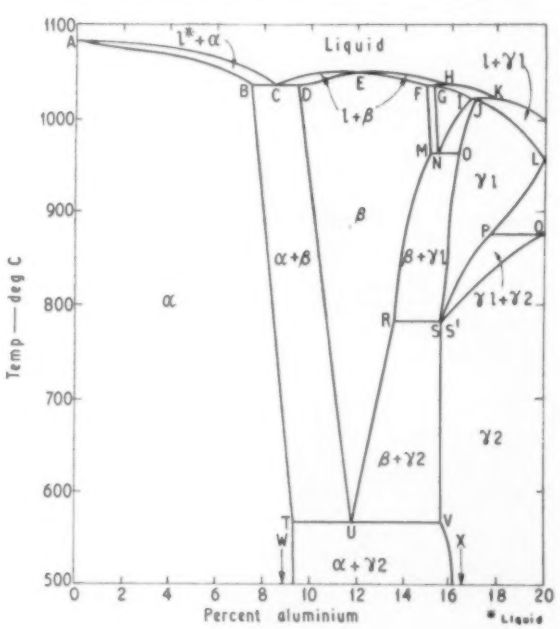


Table 3—MECHANICAL PROPERTIES DETERMINED BY TESTS ON THREE DIFFERENT ALUMINIUM BRONZES AT VARIOUS TEMPERATURES

Composition per cent	*Temperature of test, deg C*	*0·5 per cent proof stress, ton/in²* A	B	C	*Tensile strength ton/in²* A	B	C	*Elongation on $4\sqrt{\text{area}}$, per cent* A	B	C	*Per cent reduction of area* A	B	C	*Young's modulus, lb/in² × 10⁶* A	B	C	*Charpy impact V-notch, ft-lb* A	B	C	*B.H.F. (carbide ball)* A	B
	−182	25·7	22·5	16·3	46·2	45·7	40·0	50	52	24	49	51	24	22·7	20·2	15·6	70	64	29	186	185
	− 59	21·7	19·8	13·5	39·6	39·5	35·5	45	46	30	55	57	26	21·6	25·6	15·3	76	75	48	170	162
Cu 89·62	− 29	22·0	19·6	14·0	39·2	38·9	35·7	44	44	32	58	56	32	25·0	24·9	17·1	78	73	37	162	161
Al 7·78	24	20·6	18·7	12·5	38·2	37·8	34·2	42	44	37	59	56	34	18·3	19·8	20·3	73	73	38	157	155
Fe 2·57	204	19·3	17·9	11·6	34·5	33·9	30·7	35	34	35	32	32	35	18·5	18·8	14·9	66	62	30	144	142
Ni 0·01	316	17·5	16·6	12·1	27·9	27·7	24·2	22	30	19	24	27	22	12·8	11·7	15·5	62	58	41	137	134
	427	6·8	7·9	8·8	11·0	11·3	13·8	52	60	18	41	54	22	6·9	9·7	10·7	43	42	27	83	84
	538	4·6	4·4	4·5	5·7	5·9	5·0	27	36	6	25	33	7	6·6	6·5	9·3	30	28	29	49	50
	−182	25·2	24·4	22·9	50·3	49·3	46·1	37	35	8	41	38	10	18·4	18·1	20·8	27	10	9	193	195
Cu 87·20	− 59	22·0	21·4	20·0	44·2	43·0	43·9	34	33	13	41	39	25	15·7	17·5	16·9	34	13	17	170	171
Al 9·20	− 29	21·1	20·9	17·9	42·9	41·9	45·5	34	31	19	44	38	27	16·5	18·0	17·7	34	14	13	168	168
Fe 3·10	24	20·7	18·0	18·2	42·2	40·2	41·7	34	32	14	44	39	20	16·1	17·4	17·2	35	16	16	165	161
Ni 0·40	204	19·2	19·6	16·7	35·6	34·6	37·4	22	20	17	22	21	22	16·5	20·0	15·3	35	19	20	152	151
Mn 0·02	316	19·2	18·7	16·6	30·1	29·0	30·5	10	10	11	13	13	18	12·4	11·5	11·3	33	19	18	148	146
Si 0·02	427	8·9	9·9	9·5	12·7	13·6	13·3	32	46	47	33	39	47	7·9	10·6	9·5	7	7	12	98	97
Zn 0·05	538	5·9	5·4	4·5	6·7	6·1	5·8	18	27	37	29	32	54	5·9	7·4	7·1	8	8	10	54	46
	−182	30·4	27·9	29·0	54·7	56·1	55·5	8	12	8	30	12	12	18·5	18·8	20·1	9	9	4	238	235
Cu 81·20	− 59	28·7	24·5	26·7	50·1	50·8	47·6	26	24	5	28	26	9	19·0	17·9	17·8	13	13	5	216	212
Al 10·10	− 29	30·0	24·9	26·6	50·7	50·5	48·9	24	23	8	29	23	11	19·1	20·1	20·8	14	13	6	209	209
Fe 3·00	24	26·4	23·9	25·4	50·2	49·6	46·9	20	21	9	21	21	13	16·9	18·1	17·9	15	14	7	200	200
Ni 4·75	204	26·1	22·5	24·4	44·9	45·9	46·2	13	16	12	15	15	13	19·7	15·5	18·4	17	15	11	188	189
Mn 0·80	316	24·2	21·8	21·7	37·7	39·2	37·4	8	10	9	9	11	11	12·3	15·9	14·3	8	8	12	181	176
Si 0·02	427	10·8	10·2	13·0	15·8	15·1	17·5	51	41	19	56	46	25	8·2	9·3	13·8	8	7	12	98	101
Zn 0·05	538	5·7	5·0	9·0	6·9	6·1	9·0	41	39	7	59	46	24	6·4	7·0	9·6	9	7	10	47	50

Condition A: Extruded; annealed at 620 deg C and quickly cooled; lightly cold drawn; re-annealed at 620 deg C and quickly cooled; roller straightened with slight reduction. Condition B: Same as A but re-annealed at 620 deg C and quickly cooled after roller-straightening. Condition C: Same as A, then carbon arc welded using a filler rod of material comparable with the base metal, and machined into test pieces. Each figure is the mean of several concordant tests.

concerning the creep properties of aluminium bronzes. It is known, however, that die-cast aluminium bronze of 7·5 per cent aluminium content gives a total creep of 1 per cent in 10,000 hours, both at 290 deg C under a stress of 4·5 ton/in² and at 450 deg C under 1·3 ton/in². Both α-β brasses and phosphor bronze are inferior to this, the corresponding temperatures being 170 and 210 deg C for Naval brass and 240 and 320 deg C for phosphor bronze with 4 per cent of tin. The figures shown in Table 4 indicate that aluminium bronze is superior to silicon bronze regarding creep, and it may be noted that, following continental practice, the manganese contents shown are higher than is usual in this country.

Table 5 shows the rather more detailed researches of Voce; temperature control was to within $\pm 0{\cdot}5$ deg C, and the extensometers used permitted the detection of a creep rate of 10^{-6} strain units per day over a period of 20 days. The results show that stresses between 6 and 10 ton/in² are allowable at 250 deg C if the creep rate is to be restricted to 0·001 per cent per day, that is, 10^{-5} in/in/day—a criterion used by the National Physical Laboratory—or from 10 to 15 ton/in² if a creep rate of 0·01 per cent per day can be tolerated. Comparable tests carried out by the same worker on cast 10 per cent tin bronzes and gun metals gave stresses of 3-4 ton/in² and 4-6 ton/in² respectively, showing the marked superiority of the aluminium bronzes.

The figures show that the stabilizing treatment, involving the conversion of the β phase into the $\alpha+\gamma 2$ complex, is accompanied by improved creep resistance at 250 deg C.

Table 4—CREEP TESTS ON ALUMINIUM BRONZES

Composition, per cent				
Copper	87·6	83·9	83·2	96·9
Aluminium	9·1	9·7	9·5	0·0
Manganese	2·4	4·2	5·0	0·7
Iron	0·7	1·6	0·3	0·0
Silicon	0·1	0·2	0·6	2·3
Zinc	0·1	0·4	0·4	0·1
Properties at Room Temperature				
Yield point, ton/in²	12·0	22·2	18·5	8·8
Tensile strength, ton/in²	34·9	41·3	47·9	22·9
Elongation, per cent	36	12	17	59
Brinell hardness	104	164	132	81
Creep Tests				
Stress in ton/in² for a total permanent extension of 0·5 per cent after 100 hr				
at 300 deg C	7·5	5·1	7·7	4·5
at 350 deg C	3·8	2·8	3·0	2·6

Exposure of the normalized material to this temperature for four weeks is likewise distinctly beneficial, owing to the partial formation of the $\gamma 2$ constituent. Thus there need be no fear that the properties of the alloys will deteriorate owing to the occurrence of such reactions during service; on the contrary, they improve.

A series of notched-bar impact tests was also carried out by the B.N.F.M.R.A., at temperatures up to 600 deg C. The method of testing was unconventional, in that an Izod machine was converted to deliver the blow in the Charpy manner, the specimen taking the form of a beam loosely resting on an anvil, instead of being clamped in a vice, as in the Izod test.

The advantage of this arrangement for testing at high temperatures is that the specimen can be transferred from the furnace to the anvil and broken within two seconds, in which period the effect of any drop in temperature is negligible. The specimen measured 6 cm × 1 cm × 1 cm and carried a standard Izod notch mid way between its ends. Although the results should not be compared directly with either conventional Izod or Charpy figures, they are consistent among themselves.

The formation of the $\gamma 2$ constituent, as a result of the stabilizing treatment, does not seriously impair the tensile properties: it actually increases the resistance to creep, but Table 6 shows that it does considerably diminish the notched-bar value at temperatures up to 450 deg C. Above this temperature, the difference between the normalized and stabilized conditions disappears, owing to the relatively rapid change of the normalized β into the stable $\alpha+\gamma 2$ while the specimen is in the furnace prior to test.

A feature of the results for the normalized and forged materials is a well defined maximum notched-bar value at 350 deg C. This is probably connected with the presence of the β phase, for high notched-bar values are equally characteristic at 600 deg C, where any $\alpha+\gamma 2$ which may have been formed reverts to β on crossing the eutectoid horizontal at 565 deg C.

At a temperature between 200 and 300 deg C, a similar maximum is shown by the results in Table 3 for the two alloys containing more than 9 per cent aluminium. However, these tests were not carried to sufficiently high temperatures to reveal the subsequent increase in impact value which occurs on crossing the eutectoid horizontal. At low temperatures, notched-bar values tend to fall slightly, as shown in Table 3. The Brinell hardness tests shown in Table 3 were

made with a tungsten carbide ball, in order to avoid any possible softening of a steel indenter at the temperatures involved. In all cases, the hardness values diminished regularly as the temperature was raised from −180 deg C to 320 deg C, and thereafter fell more rapidly.

An investigation into the resistance to oxidation and scaling of several aluminium bronzes at 400 deg C in air, with and without additions of moisture, sulphur dioxide and hydrochloric acid gas, was also carried out by Hallowes and Voce. Weighed specimens were heated for five-hour periods under the required conditions, allowed to cool and reweighed after brushing away any loose scale. This cycle of operations was repeated until a constant loss of weight per cycle was attained. The results expressed in the practical terms of thickness of metal removed during ten such five-hour cycles are shown in Table 7. Deoxidized arsenical copper, so widely used for locomotive fire box plates and similar purposes where oxidation is liable to occur at high temperatures, is included for comparison.

All the aluminium bronzes were resistant to dry and moist air at 400 deg C, although slight adherent scales were formed, especially on the 2 per cent and the 5 per cent aluminium alloys. The addition of 0·1 per cent of sulphur dioxide to the atmosphere caused perceptible loss of weight on the alloy containing 2 per cent aluminium, while increasing the concentration of sulphur dioxide to 5 per cent instigated relatively rapid, but somewhat erratic, attack on all the materials except the 10 per cent alloy containing 2 per cent of iron, and the 12 per cent aluminium bronze, both of which offered great resistance to this highly sulphurous atmosphere. Moist air containing 0·1 per cent of hydrochloric acid gas was, as might be expected, deleterious to all the aluminium bronzes, although they showed good resistance compared with the deoxidized arsenical copper.

These results confirm the beneficial effect of aluminium in preventing oxidation at high temperatures. The thin film of alumina, Al_2O_3, which forms on the surface is highly protective, unless relatively high concentrations of chemically active substances such as sulphur dioxide or hydrochloric acid are present in the atmosphere. It is possible to improve

Table 6—NOTCHED-BAR IMPACT TESTS AT ELEVATED TEMPERATURES

Composition, per cent						
Copper	89·89		87·07		85·91	80·66
Aluminium	10·06		10·13		9·95	9·33
Iron	0·04		2·80		4·17	5·20
Nickel	—		—		—	4·81
Temperature, deg C	Notched-bar value, ft-lb					
	Normalized	Stabilized	Normalized	Stabilized	Forged	Forged
Room temp.	60	8	27	6	13	13
200	58	10	28	6	15	16
250	59	9	34	7	17	20
300	80	9	36	8	20	22
350	58	9	28	6	19	18
400	30	10	15	9	14	18
450	15	14	8	9	12	17
500	13	16	10	13	14	14
550	19	26	21	19	18	12
600	78	73	46	46	38	14

Normalized: 1 hr at 900 deg C, cooled in air; structure of matrix α + β.
Stabilized: Normalized as above, reheated 3 days at 500 deg C and cooled during 3 days; structure of matrix α + (α + γ2).

Table 5—RESULTS OF A WIDE RANGE OF CREEP TESTS ON A SELECTION OF ALUMINIUM BRONZES

a	b	c	d	e	*Total strain* f	g	h	*Strain rate per day* i	j	*n* k	l
Cu 89·91 Al 10·06	sand cast	250	5·0	15	0·091	0·136	—	0·0035	—	—	—
			8·5	27	0·293	0·541	—	0·0123	—	—	—
			12·0	34	0·709	1·181	—	0·0346	—	—	—
Cu 89·52 Al 10·47 Fe 0·01	normalized	250	1·0	26	0·020	0·027	0·035	0·0004	<0·0001	6·3	10·5
			5·0	51	0·091	0·121	0·153	0·0020	0·0005	,,	,,
			8·5	92	0·180	0·320	0·495	0·0084	0·0032	,,	,,
	soaked, 250 deg C	250	1·0	38	0·016	0·021	0·030	0·0003	<0·0001	7·2	12·0
			5·0	40	0·094	0·116	0·143	0·0016	0·0003	,,	,,
			8·5	62	0·168	0·255	0·370	0·0063	0·0020	,,	,,
	stabilized	250	8·0	40	—	—	—	—	0·0008	8·5	13·3
			8·5	56	0·110	0·156	0·232	0·0045	0·0010	,,	,,
			10·0	40	—	—	—	—	0·0020	,,	,,
			12·0	59	0·187	0·294	0·598	0·0127	0·0080*m*	,,	,,
			12·0	40	—	—	—	0·0120*m*	—	,,	,,
		400	1·5	42	0·076	0·135	0·185	0·0040	0·0011	1·4	2·7
			2·0	40	—	—	—	—	0·0027	,,	,,
			3·0	40	—	—	—	—	0·0110	,,	,,
			4·0	18*b*	—	—	—	0·34*m*	—	,,	,,
			6·0	2*b*	—	—	—	3·9*m*	—	,,	,,
Cu 86·86 Al 9·7 Fe 3·4	sand cast	250	5·0	15	0·086	0·121	—	0·0019	—	—	—
			8·5	27	0·150	0·216	—	0·0070	—	—	—
			12·0	34	0·362	0·600	—	0·0249	—	—	—
Cu 87·07 Al 10·13 Fe 2·8	normalized	250	1·0	34	0·012	0·016	0·022	0·0003	<0·0001	6·7	12·3
			5·0	40	0·073	0·093	0·121	0·0017	0·0005	,,	,,
			8·5	56	0·138	0·220	0·352	0·0063	0·0021	,,	,,
	soaked, 250 deg C	250	1·0	34	0·008	0·011	0·016	0·0002	<0·0001	7·0	12·6
			5·0	48	0·071	0·089	0·116	0·0015	0·0005	,,	,,
			8·5	55	0·141	0·190	0·290	0·0060	0·0018	,,	,,
	stabilized	250	8·0	56	0·108	0·149	0·184	0·0031	0·0005	9·5	14·5
			10·0	56	0·137	0·228	0·302	0·0062	0·0012	,,	,,
			12·0	56	0·177	0·289	0·448	0·0082	0·0032	,,	,,
	stabilized	400	2·5	47	0·041	0·108	0·196	0·0065	0·0015	2·3	3·9
			3·5	57	0·052	0·175	0·367	0·0090	0·0049	,,	,,
			4·5	56	0·074	0·375	1·84	0·0330	0·029*m*	,,	,,
Cu 80·48 Al 9·5 Fe 5·2 Ni 4·8	sand cast	250	5·0	27	0·092	0·110	—	0·0009	—	—	—
			8·5	27	0·093	0·143	—	0·0029	—	—	—
			12·0	34	0·178	0·268	—	0·0077	—	—	—
Cu 80·44 Al 9·86 Fe 4·97 Ni 4·87	extruded	250	1·0	49	0·012	0·015	0·016	<0·0001	<0·0001	9·8	15·3
			2·5	49	0·029	0·041	0·051	0·0004	<0·0001	,,	,,
			4·0	49	0·047	0·062	0·068	0·0008	<0·0001	,,	,,
			6·0	60	0·079	0·106	0·123	0·0013	0·0002	,,	,,
			9·0	60	0·119	0·186	0·236	0·0027	0·0008	,,	,,
			14·0	53	0·183	0·340	0·622	0·0133	0·0062	,,	,,
		400	3·0	30	0·047	0·188	0·430	0·0105	0·0060	3·0	3·7
			4·0	30	0·060	0·266	0·760	0·0198	0·0130	,,	,,
			5·0	30	0·076	0·620	1·930	0·0520	0·0330	,,	,,

m minimum; b broke. (a) *Per cent composition* (b) *Condition: normalized—1 hr at 825 deg C and cooled in air, structure of matrix α + β; soaked at 250 deg C—normalized as above and soaked for 4 weeks at 250 deg C, structure of matrix α + β with incipient formation of (α + γ2); stabilized—normalized as above, held for 3 days at 500 deg C and slowly cooled during 3 days, structure of matrix α + (α + γ2)* (c) *Temperature of test, deg C* (d) *Initial stress, ton/in²* (e) *Duration of test, days* (f) *Immediately after loading, per cent* (g) *At 5th day, per cent* (h) *At 40th day, per cent* (i) *At 5th day, per cent* (j) *At 40th day, per cent* (k) *0·001 per cent per day* (l) *0·01 per cent per day* (n) *Approximate stress for a strain rate after 40 days ton/in².*

Table 3—MECHANICAL PROPERTIES DETERMINED BY TESTS ON THREE DIFFERENT ALUMINIUM BRONZES AT VARIOUS TEMPERATURES

Composition per cent	Temperature of test, deg C	0·5 per cent proof stress, ton/in²			Tensile strength ton/in²			Elongation on $\sqrt{}$ area, per cent			Per cent reduction of area			Young's modulus, lb/in² × 10⁶			Charpy impact V-notch, ft-lb			B.H.F. (carbide ball)	
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B
Cu 89·62 Al 7·78 Fe 2·57 Ni 0·01	−182	25·7	22·5	16·3	46·2	45·7	40·0	50	52	24	49	51	24	22·7	20·2	15·6	70	64	29	186	185
	− 59	21·7	19·8	13·5	39·6	39·5	35·5	45	46	30	55	57	26	21·6	25·6	15·3	76	75	48	170	162
	− 29	22·0	19·6	14·0	39·2	38·9	35·7	44	44	32	58	56	32	25·0	24·9	17·1	78	73	37	162	161
	24	20·6	18·7	12·5	38·2	37·8	34·2	42	44	37	59	56	34	18·3	19·8	20·3	73	73	38	157	155
	204	19·3	17·9	11·6	34·5	33·9	30·7	35	34	35	32	32	35	18·5	18·8	14·9	66	62	30	144	142
	316	17·5	16·6	12·1	27·9	27·7	24·2	22	30	19	24	27	22	12·8	11·7	15·5	62	58	41	137	134
	427	6·8	7·9	8·8	11·0	11·3	13·8	52	60	18	41	54	22	6·9	9·7	10·7	43	42	27	83	84
	538	4·6	4·4	4·5	5·7	5·9	5·0	27	36	6	25	33	7	6·6	6·5	9·3	30	28	29	49	50
Cu 87·20 Al 9·20 Fe 3·10 Ni 0·40 Mn 0·02 Si 0·02 Zn 0·05	−182	25·2	24·4	22·9	50·3	49·3	46·1	37	35	8	41	38	10	18·4	18·1	20·8	27	10	9	193	195
	− 59	22·0	21·4	20·0	44·2	43·0	43·9	34	33	13	41	39	25	15·7	17·5	16·9	34	13	17	170	171
	− 29	21·1	20·9	17·9	42·9	41·9	45·5	34	31	19	44	38	27	16·5	18·0	17·7	34	14	13	168	168
	24	20·7	18·0	18·2	42·2	40·2	41·7	34	32	14	44	39	20	16·1	17·4	17·2	35	16	16	165	161
	204	19·2	19·6	16·7	35·6	34·6	37·4	22	20	17	22	21	22	16·5	20·0	15·3	35	19	20	152	151
	316	19·2	18·7	16·6	30·1	29·0	30·5	10	10	11	13	13	18	12·4	11·5	11·3	33	19	18	148	146
	427	8·9	9·9	9·5	12·7	13·6	13·3	32	46	47	33	39	47	7·9	10·6	9·5	7	7	12	98	97
	538	5·9	5·4	4·5	6·7	6·1	5·8	18	27	37	29	32	54	5·9	7·4	7·1	8	8	10	54	46
Cu 81·20 Al 10·10 Fe 3·00 Ni 4·75 Mn 0·80 Si 0·02 Zn 0·05	−182	30·4	27·9	29·0	54·7	56·1	55·5	8	12	8	30	12	12	18·5	18·8	20·1	9	9	4	238	235
	− 59	28·7	24·5	26·7	50·1	50·8	47·6	26	24	5	28	26	9	19·0	17·9	17·8	13	13	5	216	212
	− 29	30·0	24·9	26·6	50·7	50·5	48·9	24	23	8	29	23	11	19·1	20·1	20·8	14	13	6	209	209
	24	26·4	23·9	25·4	50·2	49·6	46·9	20	21	9	21	21	13	16·9	18·1	17·9	15	14	7	200	200
	204	26·1	22·5	24·4	44·9	45·9	46·2	13	16	12	15	15	13	19·7	15·5	18·4	17	15	11	188	189
	316	24·2	21·8	21·7	37·7	39·2	37·4	8	10	9	9	11	11	12·3	15·9	14·3	8	8	12	181	176
	427	10·8	10·2	13·0	15·8	15·1	17·5	51	41	19	56	46	25	8·2	9·3	13·8	8	7	12	98	101
	538	5·7	5·0	9·0	6·9	6·1	9·0	41	39	7	59	46	24	6·4	7·0	9·6	9	7	10	47	50

Condition A: Extruded; annealed at 620 deg C and quickly cooled; lightly cold drawn; re-annealed at 620 deg C and quickly cooled; roller straightened with slight reduction. Condition B: Same as A but re-annealed at 620 deg C and quickly cooled after roller-straightening. Condition C: Same as A, then carbon arc welded using a filler rod of material comparable with the base metal, and machined into test pieces. Each figure is the mean of several concordant tests.

concerning the creep properties of aluminium bronzes. It is known, however, that die-cast aluminium bronze of 7·5 per cent aluminium content gives a total creep of 1 per cent in 10,000 hours, both at 290 deg C under a stress of 4·5 ton/in² and at 450 deg C under 1·3 ton/in². Both α-β brasses and phosphor bronze are inferior to this, the corresponding temperatures being 170 and 210 deg C for Naval brass and 240 and 320 deg C for phosphor bronze with 4 per cent of tin. The figures shown in Table 4 indicate that aluminium bronze is superior to silicon bronze regarding creep, and it may be noted that, following continental practice, the manganese contents shown are higher than is usual in this country.

Table 5 shows the rather more detailed researches of Voce; temperature control was to within $\pm 0{\cdot}5$ deg C, and the extensometers used permitted the detection of a creep rate of 10^{-6} strain units per day over a period of 20 days. The results show that stresses between 6 and 10 ton/in² are allowable at 250 deg C if the creep rate is to be restricted to 0·001 per cent per day, that is, 10^{-5} in/in/day—a criterion used by the National Physical Laboratory—or from 10 to 15 ton/in² if a creep rate of 0·01 per cent per day can be tolerated. Comparable tests carried out by the same worker on cast 10 per cent tin bronzes and gun metals gave stresses of 3-4 ton/in² and 4-6 ton/in² respectively, showing the marked superiority of the aluminium bronzes.

The figures show that the stabilizing treatment, involving the conversion of the β phase into the $\alpha+\gamma 2$ complex, is accompanied by improved creep resistance at 250 deg C.

Table 4—CREEP TESTS ON ALUMINIUM BRONZES

Composition, per cent				
Copper	87·6	83·9	83·2	96·9
Aluminium	9·1	9·7	9·5	0·0
Manganese	2·4	4·2	5·0	0·7
Iron	0·7	1·6	0·3	0·0
Silicon	0·1	0·2	0·6	2·3
Zinc	0·1	0·4	0·4	0·1
Properties at Room Temperature				
Yield point, ton/in²	12·0	22·2	18·5	8·8
Tensile strength, ton/in²	34·9	41·3	47·9	22·9
Elongation, per cent	36	12	17	59
Brinell hardness	104	164	132	81
Creep Tests				
Stress in ton/in² for a total permanent extension of 0·5 per cent after 100 hr				
at 300 deg C	7·5	5·1	7·7	4·5
at 350 deg C	3·8	2·8	3·0	2·6

Exposure of the normalized material to this temperature for four weeks is likewise distinctly beneficial, owing to the partial formation of the $\gamma 2$ constituent. Thus there need be no fear that the properties of the alloys will deteriorate owing to the occurrence of such reactions during service; on the contrary, they improve.

A series of notched-bar impact tests was also carried out by the B.N.F.M.R.A., at temperatures up to 600 deg C. The method of testing was unconventional, in that an Izod machine was converted to deliver the blow in the Charpy manner, the specimen taking the form of a beam loosely resting on an anvil, instead of being clamped in a vice, as in the Izod test.

The advantage of this arrangement for testing at high temperatures is that the specimen can be transferred from the furnace to the anvil and broken within two seconds, in which period the effect of any drop in temperature is negligible. The specimen measured 6 cm × 1 cm × 1 cm and carried a standard Izod notch mid way between its ends. Although the results should not be compared directly with either conventional Izod or Charpy figures, they are consistent among themselves.

The formation of the $\gamma 2$ constituent, as a result of the stabilizing treatment, does not seriously impair the tensile properties: it actually increases the resistance to creep, but Table 6 shows that it does considerably diminish the notched-bar value at temperatures up to 450 deg C. Above this temperature, the difference between the normalized and stabilized conditions disappears, owing to the relatively rapid change of the normalized β into the stable $\alpha+\gamma 2$ while the specimen is in the furnace prior to test.

A feature of the results for the normalized and forged materials is a well defined maximum notched-bar value at 350 deg C. This is probably connected with the presence of the β phase, for high notched-bar values are equally characteristic at 600 deg C, where any $\alpha+\gamma 2$ which may have been formed reverts to β on crossing the eutectoid horizontal at 565 deg C.

At a temperature between 200 and 300 deg C, a similar maximum is shown by the results in Table 3 for the two alloys containing more than 9 per cent aluminium. However, these tests were not carried to sufficiently high temperatures to reveal the subsequent increase in impact value which occurs on crossing the eutectoid horizontal. At low temperatures, notched-bar values tend to fall slightly, as shown in Table 3. The Brinell hardness tests shown in Table 3 were

made with a tungsten carbide ball, in order to avoid any possible softening of a steel indenter at the temperatures involved. In all cases, the hardness values diminished regularly as the temperature was raised from −180 deg C to 320 deg C, and thereafter fell more rapidly.

An investigation into the resistance to oxidation and scaling of several aluminium bronzes at 400 deg C in air, with and without additions of moisture, sulphur dioxide and hydrochloric acid gas, was also carried out by Hallowes and Voce. Weighed specimens were heated for five-hour periods under the required conditions, allowed to cool and reweighed after brushing away any loose scale. This cycle of operations was repeated until a constant loss of weight per cycle was attained. The results expressed in the practical terms of thickness of metal removed during ten such five-hour cycles are shown in Table 7. Deoxidized arsenical copper, so widely used for locomotive fire box plates and similar purposes where oxidation is liable to occur at high temperatures, is included for comparison.

All the aluminium bronzes were resistant to dry and moist air at 400 deg C, although slight adherent scales were formed, especially on the 2 per cent and the 5 per cent aluminium alloys. The addition of 0·1 per cent of sulphur dioxide to the atmosphere caused perceptible loss of weight on the alloy containing 2 per cent aluminium, while increasing the concentration of sulphur dioxide to 5 per cent instigated relatively rapid, but somewhat erratic, attack on all the materials except the 10 per cent alloy containing 2 per cent of iron, and the 12 per cent aluminium bronze, both of which offered great resistance to this highly sulphurous atmosphere. Moist air containing 0·1 per cent of hydrochloric acid gas was, as might be expected, deleterious to all the aluminium bronzes, although they showed good resistance compared with the deoxidized arsenical copper.

These results confirm the beneficial effect of aluminium in preventing oxidation at high temperatures. The thin film of alumina, Al_2O_3, which forms on the surface is highly protective, unless relatively high concentrations of chemically active substances such as sulphur dioxide or hydrochloric acid are present in the atmosphere. It is possible to improve

Table 6—NOTCHED-BAR IMPACT TESTS AT ELEVATED TEMPERATURES

Composition, per cent						
Copper	89·89		87·07		85·91	80·66
Aluminium	10·06		10·13		9·95	9·33
Iron	0·04		2·80		4·17	5·20
Nickel	—		—		—	4·81
Temperature, deg C	Notched-bar value, ft-lb					
	Normalized	Stabilized	Normalized	Stabilized	Forged	Forged
Room temp.	60	8	27	6	13	13
200	58	10	28	6	15	16
250	59	9	34	7	17	20
300	80	9	36	8	20	22
350	58	9	28	6	19	18
400	30	10	15	9	14	18
450	15	14	8	9	12	17
500	13	16	10	13	14	14
550	19	26	21	19	18	12
600	78	73	46	46	38	14

Normalized: 1 *hr at* 900 *deg C, cooled in air; structure of matrix* $\alpha+\beta$.
Stabilized: *Normalized as above, reheated* 3 *days at* 500 *deg C and cooled during* 3 *days; structure of matrix* $\alpha+(\alpha+\gamma 2)$.

Table 5—RESULTS OF A WIDE RANGE OF CREEP TESTS ON A SELECTION OF ALUMINIUM BRONZES

a	b	c	d	e	Total strain f	Total strain g	Total strain h	Strain rate per day i	Strain rate per day j	n k	n l
Cu 89·91 Al 10·06	sand cast	250	5·0	15	0·091	0·136	—	0·0035	—	—	—
			8·5	27	0·293	0·541	—	0·0123	—	—	—
			12·0	34	0·709	1·181	—	0·0346	—	—	—
Cu 89·52 Al 10·47 Fe 0·01	normalized	250	1·0	26	0·020	0·027	0·035	0·0004	<0·0001	6·3	10·5
			5·0	51	0·091	0·121	0·153	0·0020	0·0005	,,	,,
			8·5	92	0·180	0·320	0·495	0·0084	0·0032	,,	,,
	soaked, 250 deg C	250	1·0	38	0·016	0·021	0·030	0·0003	<0·0001	7·2	12·0
			5·0	40	0·094	0·116	0·143	0·0016	0·0003	,,	,,
			8·5	62	0·168	0·255	0·370	0·0063	0·0020	,,	,,
	stabilized	250	8·0	40	—	—	—	—	0·0008	8·5	13·3
			8·5	56	0·110	0·156	0·232	0·0045	0·0010	,,	,,
			10·0	40	—	—	—	—	0·0020	,,	,,
			12·0	59	0·187	0·294	0·598	0·0127	0·0080*m*	,,	,,
			12·0	40	—	—	—	0·0120*m*	—	,,	,,
		400	1·5	42	0·076	0·135	0·185	0·0040	0·0011	1·4	2·7
			2·0	40	—	—	—	—	0·0027	,,	,,
			3·0	40	—	—	—	—	0·0110	,,	,,
			4·0	18*b*	—	—	—	0·34*m*	—	,,	,,
			6·0	2*b*	—	—	—	3·9*m*	—	,,	,,
Cu 86·86 Al 9·7 Fe 3·4	sand cast	250	5·0	15	0·086	0·121	—	0·0019	—	—	—
			8·5	27	0·150	0·216	—	0·0070	—	—	—
			12·0	34	0·362	0·600	—	0·0249	—	—	—
Cu 87·07 Al 10·13 Fe 2·8	normalized	250	1·0	34	0·012	0·016	0·022	0·0003	<0·0001	6·7	12·3
			5·0	40	0·073	0·093	0·121	0·0017	0·0005	,,	,,
			8·5	56	0·138	0·220	0·352	0·0063	0·0021	,,	,,
	soaked, 250 deg C	250	1·0	34	0·008	0·011	0·016	0·0002	<0·0001	7·0	12·6
			5·0	48	0·071	0·089	0·116	0·0015	0·0005	,,	,,
			8·5	55	0·141	0·190	0·290	0·0060	0·0018	,,	,,
	stabilized	250	8·0	56	0·108	0·149	0·184	0·0031	0·0005	9·5	14·5
			10·0	56	0·137	0·228	0·302	0·0062	0·0012	,,	,,
			12·0	56	0·177	0·289	0·448	0·0082	0·0032	,,	,,
	stabilized	400	2·5	47	0·041	0·108	0·196	0·0065	0·0015	2·3	3·9
			3·5	57	0·052	0·175	0·367	0·0090	0·0049	,,	,,
			4·5	56	0·074	0·375	1·84	0·0330	0·029*m*	,,	,,
Cu 80·48 Al 9·5 Fe 5·2 Ni 4·8	sand cast	250	5·0	27	0·092	0·110	—	0·0009	—	—	—
			8·5	27	0·093	0·143	—	0·0029	—	—	—
			12·0	34	0·178	0·268	—	0·0077	—	—	—
Cu 80·44 Al 9·86 Fe 4·97 Ni 4·87	extruded	250	1·0	49	0·012	0·015	0·016	<0·0001	<0·0001	9·8	15·3
			2·5	49	0·029	0·041	0·051	0·0004	<0·0001	,,	,,
			4·0	49	0·047	0·062	0·068	0·0008	<0·0001	,,	,,
			6·0	60	0·079	0·106	0·123	0·0013	0·0002	,,	,,
			9·0	60	0·119	0·186	0·236	0·0027	0·0008	,,	,,
			14·0	53	0·183	0·340	0·622	0·0133	0·0062	,,	,,
		400	3·0	30	0·047	0·188	0·430	0·0105	0·0060	3·0	3·7
			4·0	30	0·060	0·266	0·760	0·0198	0·0130	,,	,,
			5·0	30	0·076	0·620	1·930	0·0520	0·0330	,,	,,

m minimum; b broke. (**a**) *Per cent composition* (**b**) *Condition: normalized—*1 *hr at* 825 *deg C and cooled in air, structure of matrix* $\alpha+\beta$; *soaked at* 250 *deg C—normalized as above and soaked for* 4 *weeks at* 250 *deg C, structure of matrix* $\alpha+\beta$ *with incipient formation of* $(\alpha+\gamma 2)$; *stabilized—normalized as above, held for* 3 *days at* 500 *deg C and slowly cooled during* 3 *days, structure of matrix* $\alpha+(\alpha+\gamma 2)$ (**c**) *Temperature of test, deg C* (**d**) *Initial stress, ton/in²* (**e**) *Duration of test, days* (**f**) *Immediately after loading, per cent* (**g**) *At* 5*th day, per cent* (**h**) *At* 40*th day, per cent* (**i**) *At* 5*th day, per cent* (**j**) *At* 40*th day, per cent* (**k**) 0·001 *per cent per day* (**l**) 0·01 *per cent per day* (*n*) *Approximate stress for a strain rate after* 40 *days ton/in².*

Table 7—OXIDATION AND SCALING OF ALUMINIUM BRONZES

Composition, per cent							
Copper	97·93	94·33	90·20	87·07	88·89	87·92	99·41
Aluminium	2·06	5·66	9·76	10·13	11·10	12·06	—
Iron	0·01	0·008	0·039	2·80	0·006	0·02	0·002
Arsenic	—	—	—	—	—	—	0·46
Phosphorus	—	—	—	—	—	—	0·07
Nickel	—	—	—	—	—	—	0·06
Lead	—	—	—	—	—	—	0·01
Condition	Cold drawn 50 per cent		Extruded				C.d. 50 per cent
Thickness of metal removed ×0·001 in, at 400 deg C, per ten 5 hr heating cycles in:							
Dry air	0	0	0	0	0	0	0·6
Air + 10 per cent H_2O	0	0	0	0	0	0	0·5
Dry air + 0·1 per cent SO_2	0·3	0	0	0	0	0	0·8
Dry air + 5 per cent SO_2	2·2	11·4	0·8	0	0·7	0	1·5
Moist air + 0·1 per cent HCl	5·3	1·5	2·1	1·1	0·7	0·9	27·0

the oxide-resisting properties of a 95/5 copper-aluminium alloy by means of a prior selective oxidation treatment, after which it can be heated in oxygen for 4 hours at 800 deg C with scarcely any tarnishing, but the treatment confers no extra protection against air containing 5 per cent of sulphur dioxide at 400 deg C.

The preferential corrosion which sometimes occurs with the duplex aluminium bronzes is similar to the dezincification of the β constituent, which is encountered with the α-β brasses or manganese bronzes. The term de-aluminification was introduced to apply to this type of attack, which occurs mostly when the material is in service in acid solutions, such as sulphuric acid. In the determination of the effect of superheated steam on aluminium bronze, experiments with pure steam and with steam containing 1 per cent of air at 400 and 600 deg C failed to cause perceptible attack on any of the aluminium bronzes shown in Table 6. Only by the introduction of a small amount of a chemically active impurity, such as sulphur dioxide or chlorine, into the steam could any de-aluminification be induced. The exact concentration of such impurity which would prove dangerous has not been determined, but rather more than 0·1 per cent of sulphur dioxide would be necessary at 400 deg C. At temperatures up to 800 deg C the results are similar, although the corrosion caused by the presence of sulphur dioxide in steam is more severe.

Thus no difficulties need be expected in the use of aluminium bronzes for service in superheated steam provided that the steam is free from active impurities. While it should be noted that the effect of high pressure steam was not investigated, it seems unlikely that pressure itself would have any appreciable influence on the results. Aluminium bronzes are therefore particularly suitable for service at moderately high temperatures, both in respect of their mechanical properties and their resistance to the attack of various corrosive atmospheres covered by the tests outlined here. The Author is indebted to the Copper Development Association for the information used in this article.

Pressure Ventilated Clothing

PRESSURE ventilated clothing was first introduced by Plysu Products Ltd., Woburn Sands, Bletchley, Bucks, to provide the wearer with protection from radioactive dust. The clothing, which is light, comfortable and inexpensive, was developed in collaboration with the Atomic Energy Authority, which now specifies it for most operations where there is serious risk of radioactive contamination. A standard range of suits and hoods, all manufactured from p.v.c., is now available for use wherever airborne contamination, such as toxic smoke, gas or dust particles, presents a hazard. Additional uses of the clothing are for operations which involve high ambient temperatures or strenuous physical effort in confined spaces. Further details and prices may be obtained from Plysu Products Ltd.

A typical Plysu suit, pressure ventilated and manufactured from p.v.c. It is light and gives freedom of movement, with full protection

Extrusion of Aluminium

PRESS capacity available may determine the lowest temperature at which a product can be extruded. On the other hand, if the temperature is too high, undesirable metallurgical changes may occur. This upper temperature limit depends on both the temperature of the billet and the heating-up of the product caused by conversion of the work of deformation into heat. Specimens of 99·5 per cent pure aluminium and a high-strength aluminium alloy, DTD 363, have been extruded in a hydraulic press at billet temperatures ranging from 20 to 450 deg C. Effects of ram speed and extrusion ratio on the extrusion pressure and temperature rise in the product have been studied.

The temperature rise resulting from the work of deformation can be large. For example, at an extrusion ratio of 200 : 1, a billet temperature of 300 deg C, and a ram speed of 30 inches per minute, there is a temperature rise with aluminium of 170 deg C. Under comparable extrusion conditions, the temperature rise in the alloy is greater than in the pure metal.

Hot shortness, or cracking of the surface of the product, occurred in the alloy under various combinations of billet temperature, extrusion ratio, and ram speed. This failure took place when the temperature of the product reached about 480 deg C. If this alloy is extruded at the usual billet temperature of 400 deg C, ram speeds must be kept low to prevent the onset of hot shortness.

For extrusion ratios greater than 4 : 1, it was found that there is a linear relationship between the extrusion pressure and the logarithm of the extrusion ratio. There is also a linear relationship between extrusion pressure and billet temperature. Preliminary investigations of the effects of extrusion conditions on the hardness, tensile strength, and dimensional accuracy of the product have also been made. Further information is given in *MERL Plasticity Report* No. 146, "Extrusion of metals; Part 7—Pure aluminium and aluminium alloy D.T.D. 363," by K. Ashcroft and G. S. Lawson. Part 6, dealing with cold extrusion under impact conditions, is reviewed on page 368 of this issue.

Gas Sampling Valve

Device for Use in the Study of the Complex Changes that Take Place in the Combustion Chamber of an Automobile Engine

A QUICK-ACTING mechanical device that takes samples of a rapidly changing gas over extremely short intervals — 0·2 millisecond or less — has been developed recently by W. J. Levedahl of the U.S. National Bureau of Standards. This new gas sampling valve has been designed for use in research on the mechanism of engine knock, and is particularly well adapted to studies of the complex changes that take place in the combustion chamber of an automobile engine.

In an effort to obtain information that will make possible more efficient utilization of automotive fuels, the Bureau, with the co-operation of the U.S. Army Ordnance Department, is now studying the kinetics of knocking combustion. A single-cylinder test engine, in which a wide range of operating conditions can be simulated, has been constructed, and the data obtained with it on the igniting fuel-air mixture are being used to correlate the knocking characteristics of fuels with their chemical structure.

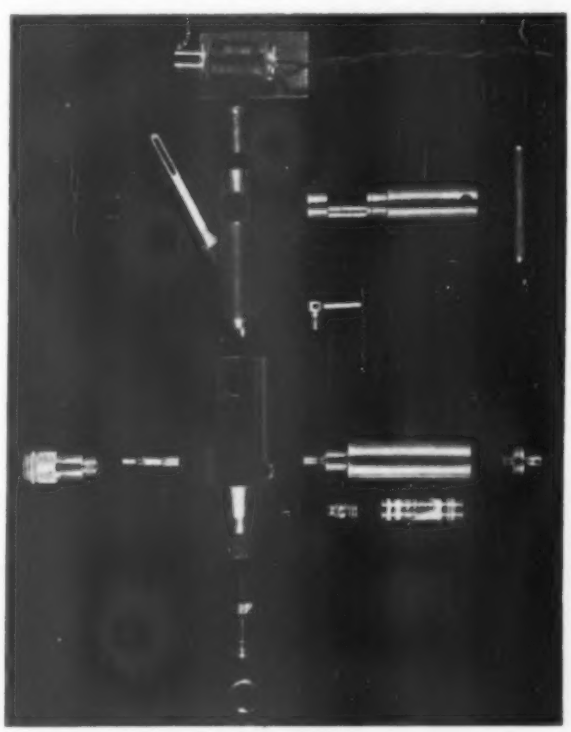
To obtain significant data on the chemical processes taking place in the cylinders, some knowledge is required of the proportions of reactants and products present at various times during the combustion cycle. However, multistage combustion reactions of this type are especially difficult to study because of the very short duration—between 0·1 and 1 millisecond—of each stage, the extreme complexity of the reaction mechanism, and the fact that many of the important particles are free radicals whose half-lives are probably 1 millisecond or less. Therefore, if the combustion gases are required to be studied, the samples must be taken over extremely short intervals during a single cycle of operation, and the reaction must be frozen almost completely upon removal of the gases from the combustion chamber. At the same time, the samples must be large enough for a complete analysis in a mass spectrometer, and the length of the sampling interval must be accurately known to permit correlation between the gas composition and the other measured quantities. The new gas sampler that is described in this article was developed to meet these requirements.

Essentially the sampling valve consists of a flanged piston, which moves in an evacuated chamber. The chamber is connected at its upper end to a vacuum pump and an evacuated sample-container. Its lower end first widens abruptly and then narrows to form a connection with the combustion chamber. Initially the valve is closed manually by pressing the piston down so that its lapped flange seats against the edge of the opening to the combustion chamber. The short length of piston below the flange extends into the opening, completely sealing it off. The valve is held in this position by a trigger device external to the valve chamber. When the trigger is released by a solenoid mechanism, the pressure of the gases in the combustion chamber accelerates the piston upward through the valve chamber so that it is moving with appreciable velocity by the time its lower edge passes out of the combustion chamber opening. At this point, the gases begin passing around the piston head and continue to do so until the upper edge of the head enters the smaller-diameter upper portion of the valve chamber, where the flange seats again and completely closes the valve. If bouncing occurs, it is not sufficient to reopen the valve.

While the piston is rising, the connection to the vacuum pump is kept closed, so that all the combustion gases pass into the sample container. Meanwhile, an upward extension of the piston progressively cuts off the passage of light from a flashlight bulb to a small 1P42 photo-electric cell. Thus, when the electric output is differentiated, a square wave indicating the time of opening and closing of the valve is obtained on the screen of an oscilloscope used to indicate pressure changes within the cylinder. Any bouncing or reopening that might occur would also be made visually evident in this way.

In general, the duration of valve opening and the total mass of gas admitted are dependent upon cylinder pressure at the time of the valve opening. Thus, for example, if the pressure is 80 lb/in^2, about 1 millilitre of gas, as measured at standard temperature and pressure, will flow in 0·2 millisecond; while at 500 lb/in^2, the flow is approximately 4 millilitres in 0·1 millisecond. This decrease in the duration of sampling with increasing pressure is advantageous inasmuch as the reactions studied occur more rapidly under these conditions in the internal combustion power unit.

Components of the gas sampling valve. At the top is the solenoid that actuates the trigger, which is below it on the left, to release the valve piston. To the right of the trigger assembly is the manually operated cam for closing the valve; the small set screw is for locking the cam. Below it are the flashlight bulb, battery and holder, with the components of the photo-electric cell on the left. The valve chamber is between these two latter assemblies, and the piston and lower valve-seat are arranged vertically in line below it, at the bottom of the illustration



Recent Foreign Publications

Brief Reviews of Current Technical Books

Nekotorie Voprosi Ochistki Vosduha u Traktornih Dvigatelei. (Some Questions Relating to the Cleaning of Air for Tractor Engines.)

In Russian, by S. A. Shtshurov and F. A. Bondarenko.
Moscow: MASHGIS. 1958. $8\frac{3}{4} \times 5\frac{1}{8}$. 107 pp. Price 3 roub 75 kg (3s).

Problems of efficient air cleaning were only partially appreciated before the last war, when the relatively short life of the engines of cross-country vehicles, such as tractors and the various types of fighting vehicles, was regarded as a natural consequence of this heavy duty. During the war, particularly in North Africa, it became abundantly clear that efficient air cleaning, despite penalties in respect of first cost, space requirements and, possibly, maintenance costs, was still a low price to pay for extended engine life. The resultant air cleaner development was of considerable benefit to the automotive industry, particularly its tractor and earth-moving sector, not only in terms of more effective cleaners, but also by providing it with a reliable test procedure and an appreciation that efficient air cleaning is worth paying for in terms of first cost and space. In this connection, the formation of B.S. 1701 and 2806 was particularly beneficial.

The appreciable amount of fundamental and applied work carried out in this country has been dealt with by Heywood, Koffman, Robotham and Worth, to name but a few, whilst work carried out in the U.S.A. has been published from time to time notably in the form of papers presented to the S.A.E. In the book under review, work devoted to the development, design and testing of tractor air cleaners, carried out at the Tractor Scientific Research Institute (N.A.T.I.), is dealt with. It is of particular interest in that it not only shows some of the aspects of the work in Russia and the resultant trend of development there, but also gives the Russian evaluation of British, American and West European tractor air cleaners.

This book comprises four separate papers, three of which are by the first-named author whilst the last one is a joint effort by both authors. The first paper, 24 pages, deals with the effect of dust in respect of tractor engine wear and the means of reducing it. First, the author considers the chemical composition of airborne dusts encountered in the Odessa and Moscow districts, and then he reviews the results of engine wear tests described in the *Automobile Engineer*, January 1948, and in the *S.A.E. Journal*, March, 1953, as well as tests carried out in Russia on type DT-54 tractor engines. The results of tests carried out to determine the airborne dust density around tractors are given, together with typical particle size distributions. Next the author gives, in considerable detail, the results of tests carried out to ascertain and then to improve the efficiency of the two-stage cleaner used with DT-54 tractors. These tests were concentrated mainly on the development of more efficient scrubber elements. The results are considered with particular reference to the dust-holding capacity relative to total pressure rise. In the next paper, six pages are devoted to the determination of cleaner efficiency as a function of particle size, along the lines proposed by Heywood and published in the proceedings of the Institution of Mechanical Engineers, 1952. The method is applied to test results obtained with a N.A.T.I. designed, cyclone pre-cleaner.

In the following paper, 21 pages, the fundamentals and performance of cyclone pre-cleaners are discussed. Here, the author is concerned with fundamental aerodynamic considerations relating to the flow of air and the passage of dust particles through a cyclone unit, the performance of representative equipment and the action of an exhaust operated ejector used to remove the rejected dust. The use of the latter has proved to be beneficial, but the possibility of causing fires as a result of the passage of combustible dust into the exhaust is mentioned. Also considered in detail are the design and performance of a new cyclone pre-cleaner developed by N.A.T.I. for tractor DT-54; the working drawings of this unit as well as of an exhaust ejector are given as an appendix at the end of the book. It is surprising that, in this section, the results of the very extensive theoretical and experimental investigations published by Prof. Feifel, of Vienna, have been overlooked.

The final paper occupies about one half of the book. It covers in some detail the design and performance of five Russian two-stage air cleaners for tractors, two East German and seven West German, one Czechoslovak, one U.S.A. and seven British cleaners, the latter including units as used with Ford, Nuffield, David Brown and Ferguson tractors. It is noted that the Russian designs are, by and large, some 2 to $2\frac{1}{2}$ times heavier than equivalent foreign makes, but that the efficiencies of some of the latter were found to be inferior. Attention is drawn to the development of self-emptying cyclone pre-cleaners and the necessity of reducing the weight of oil-bath units, and in this respect it is considered that particular attention should be paid to the avoidance of adversely affecting efficiency.

Über Verbrennungsmotoren und Kraftfahrwesen. (About Internal Combustion Engines and Motor Car Matters.) Vol. 2.

In German, by Prof. Alfred Jante et al.
Berlin: V.E.B. VERLAG TECHNIK. 1959. $8\frac{1}{4} \times 6$. 740 pp. Price D.M. 34.00.

Work concerned with the development of efficient transportation is facilitated by the prevailing climate of scientific approach and is gathering momentum. This is mainly as the result of the work of individual companies and the large laboratories set up at the more progressive universities and technical high schools. Research carried out by senior and post-graduate students under the dynamic leadership of outstanding engineers and teachers, such as Prof. Jante at Dresden and Prof. van Eldik Thieme at Delft, is of particular value, since an effort is made to concentrate on investigations, relating to topical problems and recent results, of direct and immediate use to the industry and to other research and development workers. Whilst the results of many of these investigations are published in technical journals, the notion of collecting and publishing them in book form is a welcome one, since it facilitates study and reference. Earlier work of the Institute for Internal Combustion Engines and Motor Vehicles (IVK) at the Technical High School at Dresden, headed by Prof. Jante, was published in a volume reviewed in the April 1957 issue of *Automobile Engineer*. Since then much useful work has been accomplished, and the numerous papers dealing with it have been published in this, the second volume of what now appears to be a regular and welcome series.

Following a brief introduction by Prof. Jante, dealing with the work carried out at the Institute, the volume is divided into two main sections, one, of 570 pages, devoted to engine performance and research, while the other, of 165 pages, is on vehicle performance and evolution. The first two papers, by Horn, deal with the causes and the possible prevention of valve gear cam wear. Since friction is obviously the main cause, it is considered in detail and the theoretical considerations are substantiated by the results of tests carried out with special rigs.

In the next paper, Prof. Jante deals with theoretical aspects of valve cam design, aiming at smooth performance characteristics, in order to obviate the possibility of spring surging. A device for measuring piston ring tension is described by Richter, whilst Hinze considers the thermodynamic evaluation of indicator diagrams. In the following paper, Prof. Jante deals with the possibilities in respect of automobile engine development, with particular reference to part-load fuel consumption and the desirability of matching engine and fuel performance when the compression ratio is increased. So far as the question as to the relative merits of internal combustion engines or gas turbines is concerned, the author is of the opinion that at present the answer is to combine the internal combustion engine with a turbine, that is, to turbocharge the engine; turbocharging should also bring benefits in respect of part load fuel consumption.

An outstanding section of the work is a 130 page paper, by Hofmann, on the possibilities of influencing the pattern of the torque curves of two-stroke engines with crankcase scavenging. Here, the author considers the correlation of theoretical considerations with experimental evidence. The work is very thorough and painstaking, and the exact and detailed approach to the problem of charge and scavenging flow should be very welcome to designers, particularly in view of the fact that the availability of digital computors now opens new and attractive possibilities for more precise evaluations at an early design stage.

A number of specialized problems relating to diesel engines occupy 144 pages. In this section, Novak deals with work carried out, at the Institute, on fuel pumps and two-stage governors, with particular reference to the possibility of adjusting the engine characteristics to the vehicle requirements. The correlation between the theoretically possible and the actually attained engine characteristics are impressive. In an appendix to this paper, Prof. Jante points out the necessity for developing vehicle engine governors for specific applications rather than relying on what are virtually standard units.

The development of a compound two-stroke diesel engine, type NZD 12-5, with 90 mm bore and 125 mm stroke, is described at some length by Meissner, who points out that the difficulties generally encountered with the evolution of suitable heat exchangers has detracted from the possibility of rapid development of vehicle gas turbines. Because of this, a combined two-stroke diesel engine and gas turbine power plant appears to offer many advantages. The tests carried out to determine optimum combustion chamber parameters are comprehensive and particularly interesting. A comparison of fuel consumption and general performance data suggests that further development work will be required to reduce mechanical losses —an item the importance of which has been repeatedly stressed by Sir Harry Ricardo.

Development work carried out on a single cylinder two-stroke research diesel unit, with bore and stroke dimensions of 98 mm and 124 mm respectively, is dealt with by Horn. The effect of various changes in the pre-combustion chamber design are dealt with, whilst the effects of a rotary exhaust valve, in respect of the performance of this engine, are considered in a second paper by the same author. Devices developed for direct measurement of the delivery of fuel injection pumps on test rigs are discussed by Bindermann, with particular reference to a multi-cell delivery rate analyser disc developed at the Institute.

The possibility of reducing the part-load fuel consumption of petrol engines is considered in a paper by Hauser, who deals with the effect of inlet throttling, inlet surge, valve arrangementt and compression ratio control. Rig tests carried out to determine the effectiveness of the various methods are dealt with in some detail, and this interesting paper is followed by one on the design of a six-cylinder variable compression engine by Hauser. The effect on fuel consumption of pre-heating the air mixture is then considered by Hauser and, again, theoretical considerations are substantiated by the results of extensive engine rig tests. Practical tests carried out to ascertain the performance of representative modern carburettors are considered by Freche, and are compared with the results of detailed analyses, and Müller describes the design and performance of a new IVK carburettor. Freche also considers the carburettor problems associated with two-stroke engines. Tests carried out to ascertain the performance of a *moped* engine are described by Hofmann, with particular reference to the effect of different exhaust silencer configurations.

The next section, covering 145 pages, is devoted to vehicle problems, and with one exception comprises papers by Prof. Jante. These are devoted to the future development of automobile bodywork, the performance of a 1954 Volkswagen engine, the Paris Motor Show, the Citroën DS19, air spring characteristics and the Geneva Motor Show. Two papers on the effect of hydraulic coupling and the hydraulic torque converter on vehicle fuel consumption, in different gears and over a wide range of loads, are of particular interest to designers and operators. The very important work of matching engine and transmission to achieve best performance and lowest fuel consumption in terms of vehicle performance—a subject that has also been particularly carefully studied by the Dresden School—thus receives further valuable impetus. A paper by Jahn deals with tests on vehicle chassis models, to determine stiffness and stresses, whilst the two final papers, by Richter, deal with the performance of fuel and lubricating oil filters.

This volume is a valuable contribution, and undoubtedly will stimulate further work in the various fields of automotive engineering that it covers. It is a worthy successor to the previous volume, and can be highly recommended to design and development engineers and to research workers in the various fields that it covers.

Der Mechanische Indikator.
(The Mechanical Indicator.)

In German, by P. M. Oehmichen, Prof. Dr. Ing.
Berlin: V.E.B. VERLAG TECHNIK. 1959. 2nd edition. $8\frac{1}{4} \times 6$. 176 pp. Price D.M. 19.00.

The development of electronics, coupled with an urge to carry out research in all spheres of engineering, has made the oscilloscope as much a part of the personal equipment of practically every research worker as are the spanner or screwdriver of a fitter. In consequence of this pride in the employment of complicated equipment and, also, the convenience bestowed by its use, more pedestrian though extremely useful equipment is less frequently used than is economically justifiable. The initiated know only too well the difficulties likely to be encountered in case of breakdown of the complex instrumentation, and the urge that often overtakes the research staff to evolve yet more ingenious circuits instead of getting on with the job in hand. This should not, however, detract from the employment of useful equipment, for the right applications.

It seems that the well known mechanical indicator is one of the instruments the utility of which is not always fully appreciated. Admittedly its use is limited to what, by modern standards, are slow running machines, but it is extremely useful so far as stationary and ship diesel engines and reciprocating pumps and compressors are concerned, in spite of the late Prof. Meinke's dictum that "the mechanical indicator was the best means for scientific swindle". However, it is useful to have a treatise that deals with the theory and practice of this simple, cheap and very effective device in an authoritative and exhaustive manner.

That an outstanding authority on the subject of reciprocating and rotary engines has undertaken this task, which obviously has been a labour of love, is extremely fortunate. The book under review deals with the subject in a model manner: the thoroughness, clarity and usefulness of the work leaves nothing to be desired. Covered in the first chapter are: the historical evolution of the indicator from the non-recording indicator of Watt, the simple recording one of Southern, the gradual evolution largely due to MacNaught, Richards and Crosby, to current designs. Even in this chapter, the author does not miss an opportunity to point out the difficulties encountered, owing to indicator spring oscillations, when making a diagram with a Lenoir engine in 1861. Next, typical modern indicators are briefly described, individual components being dealt with in some detail in the next chapter, which is followed by a chapter devoted to a detailed description of auxiliary equipment such as stroke reducing gear, hooks, cocks, valves and recording drums.

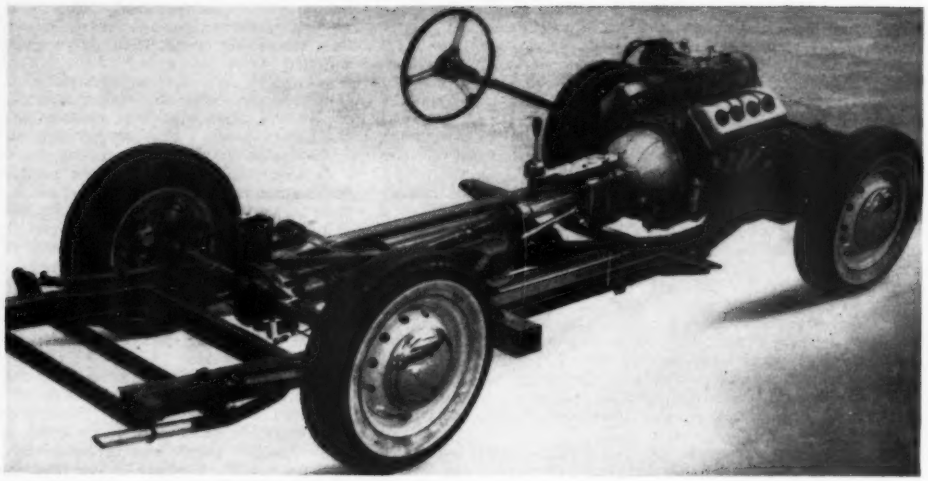
The fifth chapter is devoted to calibration equipment and procedure. In the sixth, the following are discussed: specialized indicators, as used with locomotives; maximum pressure indicators; and mean pressure indicators, as evolved by Wimperis and by Geiger. Two pages deal with the installation and diagram recording, and following this, some 25 pages and 75 illustrations are devoted to the interpretation of diagrams showing a faulty performance of the indicator itself, when used on steam engines, reciprocating compressors, refrigeration machinery, pumps and internal combustion engines.

In the next 33 pages, the work covers the evaluation of the diagrams in terms of indicated output, considerations relating to the expansion and compression strokes, harmonic analysis, planimeter use, determination of mechanical efficiency and specific heat consumption and thermal efficiency. After this, a chapter deals with indicators used to measure force and valve displacement. It is followed by a lengthy section devoted to the theoretical aspects of the indicator performance. Here, particular attention is paid to the prevention of undesirable aspects of indicator behaviour, such as irregularities due to friction, wire oscillation, drum slip, general oscillations due to flexibility of the system and resonance conditions. The avoidance of resonance requires a knowledge of the natural frequency and of the damping forces in-built in the indicator, and the determination of these two parameters is considered in detail. Some 12 pages are devoted to the limits of the use of mechanical indicators. The final chapter compares mechanical with optical and electronic indicators. In the bibliography there are 42 references, all of German origin.

This is a most thorough treatise, of direct and immediate use to research workers, development engineers and engineering teachers and students. It does full justice to a research tool of simplicity and great effectiveness. Prof. Oehmichen, and also Prof. Haussler and Dr. Schüffler, who contributed four out of the 12 chapters, are to be congratulated for the production of such a timely and useful text.

Special Number

THE Show Review number of the *Automobile Engineer* will be published on Wednesday, November 25th. It will constitute a critical review of the more interesting exhibits and will have numerous illustrations of special features and design characteristics. This special issue can be obtained by order from newsagents throughout the United Kingdom, price 3s. 6d. net. Readers are reminded that it is necessary to make arrangements with a newsagent to ensure that a copy is secured.



The compact V-eight engine of the Daimler SP250 is installed in a robust frame, with side members of box section. These pass under the rear axle

New British Cars

SUMMARY OF THE NOTEWORTHY FEATURES OF RECENTLY INTRODUCED VEHICLES

Daimler SP250

A PROTOTYPE of a new Daimler sports car, powered by a 2½-litre V-eight engine, was first exhibited in April 1959 at the New York Motor Show. This car, which has a plastics body of the open, occasional four-seater type, is now in production, though some months will elapse before it becomes available on the home market. A feature of the engine is the use of part-spherical combustion chambers, with inclined valves actuated by push rods and rockers from a single camshaft. The robust chassis embodies a cruciform bracing member and is unusual, among modern cars, in that the side members pass below the rear axle. Disc brakes are fitted to all four wheels.

The bore and stroke dimensions of the engine are 76·2 mm and 69·85 mm, giving a swept volume of 2,548 cm^3 and a stroke : bore ratio of 0·917 : 1. A side-by-side connecting rod layout is employed, and the five-bearing crankshaft has integral balance weights; the main bearing journal diameter is 2 in, and the crankpins have a diameter of 1¾ in. Copper-lead is employed for the main and big-end bearings. A bonded-rubber, torsional vibration damper is fitted to the front end of the crankshaft. Since the connecting rod length is 5¾ in, the ratio of that length to the stroke is relatively high at 2·09 : 1.

The cast iron cylinder block casting has its lower joint face on the horizontal plane through the crankshaft axis, and to it is bolted a cast aluminium sump having an oil capacity of 1½ gallons. A Renold automatic tensioner is embodied in the duplex chain drive to the camshaft, which is carried in six plain bearings, well above the crankshaft, in the 90 deg angle between the banks of cylinders. The distributor is accessibly sited vertically at the rear of the engine. It is driven by a spiral gear on the camshaft, and its shaft extends down to drive the oil pump.

Because of the use of part-spherical combustion chambers and a single camshaft, there is an appreciable angle of splay between the Duralumin inlet and exhaust push rods of each bank. Since, for ease of production, the tappets for each side are parallel and in line whereas the push rods for the inlet and exhaust valves are not, the angularity between tappets and push rods is greater than usual. The tappets, which are carried in a cast iron tappet block, have arcuate follower faces and their ball upper ends register in sockets in the push rod lower ends.

A high-grade aluminium alloy is employed for the cylinder heads, and the valve seats are of austenitic iron. The included angle between the valve stems is 70 deg, and the diameter of the valve heads is relatively large; the part-conical piston crowns are recessed at each side for clearance under the valve heads. As in the case of the Armstrong Siddeley models and the Humber Super Snipe engine, tubular inserts in the cast aluminium rocker gear covers accommodate the sparking plugs, which are installed parallel to the cylinder axes, but displaced longitudinally from the transverse plane through the valve stems. A compression ratio of 8·2 : 1 has been adopted.

The porting has been designed to provide freedom of gas flow, as has the crossover type inlet manifold. In the manifold, the ducting comprises two separate systems, each feeding the inner pair of cylinders of one bank and the outer pair on the other bank. On the manifold are mounted two transversely disposed S.U. HD6 semi-downdraught carburettors of 1¼ in bore, each of which has its own pancake type air filter. The exhaust manifolds are of four-branch design, a separate exhaust system being provided for each bank of cylinders. A cross-flow type of radiator is employed.

A gross power output of 140 b.h.p. at 5,800 r.p.m. is attributed to the engine. In other terms, this output is 55·0 b.h.p/litre, 2·48 b.h.p/in^2 piston area, 0·305 b.h.p/lb engine weight and 141·4 b.h.p/ton vehicle kerb weight. This latter figure is remarkably high, and indicates exceptional acceleration potential. At maximum b.h.p., the mean piston speed is moderate, at 2,660 ft/min. A maximum torque of 155 lb-ft at 3,600 r.p.m. is claimed: this is equivalent to the unusually high b.m.e.p. of 150·3 lb/in^2, indicative of high volumetric and thermal efficiencies. The ratio of maximum torque : torque at maximum b.h.p. is 1·22 : 1., and

that of speed at maximum torque : speed at maximum b.h.p. is 0·621 : 1. A minimum brake specific fuel consumption of 0·50 pints/b.h.p-hr is obtained at 2,500 r.p.m.

The aluminium bell-housing, bolted to the rear of the crankcase, houses a Borg and Beck single-dry-plate clutch having a diameter of 9 in and a friction area of $2 \times 32{\cdot}9$ in^2. It drives a four-speed gearbox of orthodox design, with baulk ring type synchromesh on second, third and fourth gears. As will be seen from the table of specification data, the ratios are relatively close and are satisfactorily spaced. A remote control linkage enables the short gear lever to be sited close to the driver's hand. At extra cost, Laycock-de Normanville overdrive is available; it is effective on top, third and second gears, and provides a step-up of 0·82 : 1. An open propeller shaft transmits the drive to the semi-floating live rear axle, which has a hypoid-bevel reduction of 3·58 : 1. The road speeds/1,000 r.p.m. in normal and overdrive top are respectively 20·6 and 25·1 m.p.h.

To give maximum roll stiffness for a given spring rate, the semi-elliptic rear springs are mounted as close as possible to the wheels, and in this respect the use of disc brakes is of assistance because of their relatively small axial dimensions. The spring action is controlled by lever type dampers. Rubber bump stops are mounted in inverted U-shape steel straps, of heavy gauge, attached to the frame side members and straddling the tubular portions of the axle casing. The spring rate is 156 lb/in, and the periodicity is 105 c/min. A roll centre height of 10·9 in and a roll stiffness of 1,915 lb-in/deg are quoted by the manufacturers.

At the front, an orthodox suspension layout of double transverse wishbones, of unequal length, is employed. The wishbones are of fabricated construction, and ball joints are fitted at the upper ends of the steering swivel members, to cater for both vertical and horizontal articulation. Long, helical springs form the suspension medium, and they embrace the co-axially mounted telescopic dampers. Because of the low centre of gravity of the car, and the relatively high spring rate, of 116 lb/in, no anti-roll bar is fitted. The periodicity is 85 c/min, the roll centre height is 3·06 in, and the roll stiffness 2,530 lb-in/deg. Of the kerb weight of 2,218 lb, 53 per cent is carried by the front wheels.

A Cam Gears cam-and-peg steering box has been adopted, and is connected to the front wheels by a three-piece track rod and slave lever assembly. In the straight-ahead position, the ratio is 14 : 1, and it rises to 12 : 1 on full lock. As a result of this high gearing, the steering seems relatively heavy during slow-speed manoeuvring, but it is sufficiently direct to ensure positive control at higher speeds. The steering column is well raked, and it can be fitted at extra charge with telescopic adjustment providing 3 in of travel.

It is interesting to note that Girling disc type brakes are installed at both the front and rear. At the front, 10$\frac{3}{8}$ in diameter discs are employed, and at the rear they are 10 in diameter. In each case, the discs are of high grade cast iron; the total friction pad area is 37·5 in^2, and the area swept by them is 418 in^2, of which 227 in^2 is at the front. No servo assistance is employed, because of the relatively low weight of the vehicle. The hand brake lever is of the fly-off type, widely used for racing.

As befits a high-performance sports car with a separate body, the all-welded chassis frame is of sturdy construction, with good torsional stiffness. Although, in comparison with an upswept frame design, the underslung layout gives a stiffer structure and a lower centre of gravity, it does introduce a slight complication should removal of the rear axle be necessary. It may be recalled that both the Daimler Consort and the Lanchester Ten featured this type of chassis. The side members are of box section, formed by the insertion of a shallow channel into a deeper one. They are swept inwards at the front, to provide steering clearance, and have a slight dip beneath the rear axle. At the front is a fabricated structure carrying the engine and the suspension pivots; from the upper ends of this structure, bracing members slope downwards and rearwards to the side members.

The cruciform bracing is of channel section, and is well gusseted at the intersection and at the ends of the arms. There are three additional cross members: one is of top

Daimler SP250 SPECIFICATION DATA

Engine

Number of cylinders 8, 90 deg V layout
Bore 76·2 mm
Stroke 69·85 mm
Swept volume 2,548 cm^3
Maximum b.h.p. (gross) 140 at 5,800 r.p.m.
Maximum b.m.e.p. 150·3 lb/in^2
Maximum torque 155 lb-ft at 3,600 r.p.m.
Compression ratio 8·2 : 1
Crankshaft Five-bearing, forged steel, with integral balance weights
Valves Overhead, inclined at included angle of 70 deg, push rod operated from single camshaft
Combustion chamber type Part-spherical
Carburettors Two S.U. HD6 semi-downdraught
Fuel pump S.U. electric
Dry weight 458$\frac{1}{2}$ lb, including clutch

Transmission

Clutch Borg and Beck single dry plate, 9 in diameter, with hydraulic actuation
Gearbox type Four-speed, with synchromesh on second, third and fourth. Laycock-de Normanville overdrive optional extra, operative on second, third and fourth gears
Gear ratios

	Normal	Overdrive
fourth	1 : 1	0·82 : 1
third	1·23 : 1	1·01 : 1
second	1·74 : 1	1·43 : 1
first	2·94 : 1	
reverse	3·77 : 1	

Dry weight 78$\frac{1}{2}$ lb, including bell housing but without overdrive
Propeller shaft Open, with needle roller bearing universal joints

Rear axle

Type Semi-floating, with hypoid-bevel reduction
Ratio 3·58 : 1

Suspension

Front Transverse double wishbones and coil springs, with telescopic dampers
Rear Semi-elliptic springs, with lever type dampers

Steering

Make and type Cam Gears cam-and-peg
Ratio Straight ahead 14 : 1
Full lock 12 : 1
Turning circle 33 ft 6 in
Turns from lock to lock 2·6

Brakes

Front Girling hydraulic, disc type, 10$\frac{3}{8}$ in diameter
Rear As front but 10 in diameter; mechanical actuation by hand brake
Distribution of braking effort
front 65·3 per cent
rear 34·7 per cent

Wheels and tyres

Wheel type Pressed-steel disc, with four-stud attachment
Tyre size 5·90-15 in
Pressures, normally laden
front 22 lb/in^2
rear 24 lb/in^2
Increased by 6 lb/in^2 for high-speed running
Chassis Box-section side members, underslung below rear axle; cruciform bracing member and additional cross members

Dimensions

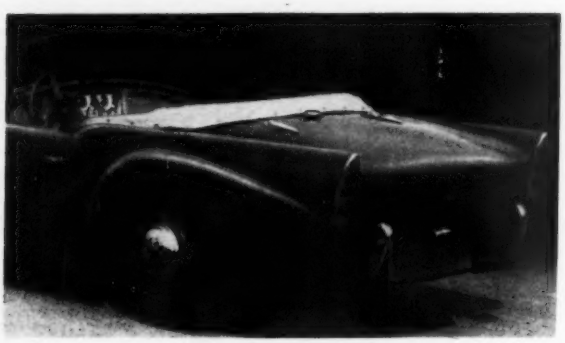
Wheelbase 7 ft 8 in
Track, front 4 ft 2 in
Track, rear 4 ft 0 in
Ground clearance 6 in
Overall length 13 ft 4$\frac{1}{2}$ in
Overall width 5 ft 0$\frac{1}{2}$ in
Overall height 4 ft 2$\frac{1}{2}$ in, with hood raised
Kerb weight, with full fuel tank 2,218 lb
Frontal area 16 ft^2

Glass reinforced polyester resin is used for the low-built body of the SP250. The flared mouldings on the sides add to the stiffness of the panels. On the upper surface of the shallow radiator grille is embodied the traditional Daimler fluting

hat section and is fitted between the side members, immediately behind the rear axle; the others are of inverted top hat section and their flanges are welded to the underside of the side members. The second is in line with the shackles of the rear springs, and the third is at the extreme rear of the side members. Of the eight body mounting points, two are on the front cross member, two more on each side are on bearer arms extending from the side members, and the final two are at the rear ends of these members. The second two bearer arms are reinforced to form the front anchorages of the rear springs.

Glass reinforced polyester resin is employed for the body, which has a good aerodynamic form and is characterized by a rising line from nose to tail. The shell is produced by the wet lay-up process in a single, six-piece split mould, and the floor also is a single moulding. At the front of the body there is a low mounted, shallow oval grille, the surround of which carries the traditional Daimler fluting on its upper surface. The bonnet line rises relatively steeply from the intake, and the side lamps, which are mounted above the headlamps, are clearly visible from the front seats. Additional stiffness is provided on the side panels and round the wheel openings by the flared moulding lines visible in the accompanying illustrations. The boot is of reasonable capacity for this type of car, and is flanked by tail fins having rearwardly raked trailing edges; the mounting for the rear number plate is moulded into the relatively high skirt panel of the boot. Within the boot is housed the spare wheel, and the 12 gallon fuel tank is installed behind the squab of the rear seat.

The tail fins have undercut trailing edges. Rear over-riders and front quarter bumpers are standard, full-width bumpers being optional extras



The windscreen, of the wrap-round type, is relatively shallow and is less steeply raked than on many sports cars. Metal-framed winding windows are fitted to the doors, and fit snugly into the plastics-coated fabric hood. This has a large, three-piece rear light and stows neatly behind the squab of the occasional rear seat. Leather is used not only for the upholstery and trim, but also to cover the padded facia panel. A leather covered steering wheel is available optionally at extra cost. The instruments include speedometer and tachometer, ammeter and gauges for fuel, water temperature and oil pressure.

A considerable range of special equipment is available at additional cost. The list contains items such as centre-lock wire wheels, a heater, safety belts, a tonneau cover, a detachable hardtop—also in glass reinforced polyester resin—and full-width bumpers in place of the standard quarter bumpers at the front and over-riders at the rear. Also, it is expected that Borg-Warner automatic transmission will be optionally available in the near future, in place of the manually controlled gearbox.

For a 2½-litre car, the SP250 has the unusually short wheelbase of 7 ft 8 in. Its ratio of wheelbase : mean track is therefore low, at 1·97 : 1. The ratios of wheelbase : overall length and mean track : overall width are respectively 0·589 : 1 and 0·802 : 1, and the frontal area is relatively small at 16 ft².

Ford Anglia, Popular and Prefect

IT has been known for some time that the Ford Motor Co. intended to introduce a replacement for the 1,172 cm³ side-valve engine, which first went into production well over 20 years ago. Although, in its latest form, this engine had a power output comparable with the 1-litre overhead valve products of competitive firms, it was inevitably inferior in terms of fuel consumption. Also, it was used with a gearbox with only three forward ratios, and the overall performance of the cars suffered accordingly. The new engine is now in production. It is a four-cylinder, overhead-valve unit of 997 cm³ swept volume, with a very short stroke; its power output and fuel economy are both superior to those of the earlier engine, and it is coupled to a four-speed gearbox.

This power unit is fitted to Ford's completely new car for 1960, the Anglia. Like its predecessor of the same name, this is a two-door saloon, but it differs markedly in appearance from any previous Dagenham product, and, in fact, from any other all-British car. In place of the familiar forward-raked rear light, with single or double curvature, the new Anglia has a flat light with a rearward rake. The advantages claimed for this departure from orthodoxy will be discussed later. In other respects—construction, suspension and general layout—the Anglia follows well-established Ford practice.

This view illustrates the reverse rake on the flat rear light of the new Ford Anglia. The boot has a large lid but a relatively high skirt panel

The new engine has a bore of 80·96 mm and a stroke of 48·41 mm, giving a stroke : bore ratio of 0·598 : 1, probably the lowest yet used in a quantity-produced unit. One may question the need to go to such extremes of over-squareness, but such dimensions should result in low weight, by virtue of the shortening of the cylinder block, connecting rods and crankshaft throws. Also, valves of ample size, for good breathing at high speed, can readily be accommodated, and the slow mean piston speed should ensure a reasonably low rate of bore wear.

As on previous Ford engines, cast iron is the material of the three-bearing crankshaft. The shaft is hollow, to minimize

Features of the two-door saloon body are a falling roof line and rather prominent headlamp mounting. On the de luxe model shown here, the radiator grille is wider than that of the standard version, and the side panels carry a bright beading

weight, and bending stresses are kept low by positioning each crankpin close to the adjacent main bearing; the large overlap between the journals provides the necessary strength and stiffness without the need of a thick web. Because of the large bore, upward withdrawal of the piston and connecting rod assembly is possible without the adoption of oblique splitting of the big-end eyes. At 2·42 : 1, the ratio of connecting rod length : stroke is considerably higher than average. Copper-lead is used for the linings of the big-end bearings, but the main bearings are of micro-babbitt. The crankcase to sump joint face is on the horizontal plane through the crankshaft axis. Chain drive is employed for the side mounted camshaft, which carries a spiral gear, between the cams of numbers 1 and 2 cylinders, to drive the inclined distributor.

The valves are actuated by mushroom footed tappets, push rods and rockers; they are disposed vertically in the cast iron cylinder head. A bath tub form of combustion chamber has been adopted, but it has an inclined wall on the right-hand side, where the sparking plug is sited. The chambers are fully machined, to ensure consistency of the clearance volumes. This is an unusual refinement in a quantity-produced engine, but is certainly desirable if the unit, with its relatively high compression ratio of 8·9 : 1, is to operate satisfactorily on normal premium fuels. Engines with a ratio of 7·5 : 1 are available for certain export markets. For optimum breathing, there are separate inlet and exhaust ports for all cylinders. The inlet manifold carries a Solex 30 ZIC-2 carburettor, with a 30 mm choke diameter, and there is the usual exhaust-heated hot spot beneath the manifold riser.

It is stated that the maximum gross power of 41 b.h.p. is produced at 5,000 r.p.m., at which the mean piston speed is only 1,588 ft/min. A torque of 52·85 lb-ft is attained at 2,700 r.p.m.: this is equivalent to a b.m.e.p. of 131 lb/in². The ratio of maximum torque : torque at maximum b.h.p. is 1·23 : 1, and that of the speeds at maximum torque and maximum b.h.p. is 0·54 : 1. According to the manufacturers, the minimum brake specific fuel consumption is 0·475 lb/b.h.p-hr. Expressed in terms of the swept volume, piston area, engine weight and vehicle kerb weight, the power output is 41·2 b.h.p/litre, 1·28 b.h.p/in², 0·187 b.h.p/lb and 56·5 b.h.p/ton.

A Ford single-dry-plate clutch, of 7¼ in diameter and with a friction area of 2×21·64 in², transmits the drive to the new four-speed gearbox. This is of orthodox design, with baulk type synchromesh on second, third and fourth gears. The short, floor-mounted gear lever actuates the selector mechanism through the medium of a built-in remote control. A rather wider spacing than usual has been adopted for the ratios, particularly between second and third gears: the forward ratios are 1 : 1; 1·412 : 1; 2·396 : 1 and 4·118 : 1, while reverse is 5·404 : 1. The semi-floating rear axle, which has a hypoid-bevel reduction of 4·125 : 1, is driven by an open propeller shaft. In conjunction with the 5·20-13 in tyres, this ratio gives a road speed of 16·1 m.p.h/1,000 r.p.m. in top gear.

The rear axle is mounted rather ahead of the middle of the 45 in long semi-elliptic springs, to increase the roll stiffness. To give a roll steer effect, the front anchorages of the springs are lower than those at the rear. Lever type dampers control the action of the springs. The front suspension design follows the sound and well-tried Ford layout of single transverse links, each triangulated against drag and brake torque reactions by the oblique, trailing ends of the anti-roll bar. Carrying the wheel is a stub axle member, which swivels on a nearly vertical telescopic strut containing the damper. A coil spring is installed between abutments on the unsprung and sprung portions of each strut, the upper end of which is pivot mounted on the body structure. The spring rate for the rear suspension is 80 lb/in on bump and 102 lb/in on rebound; that at the front is 80 lb/in, measured at the wheel. Corresponding figures for

Ford Anglia SPECIFICATION DATA

Engine

Number of cylinders 4
Bore 80·96 mm
Stroke 48·41 mm
Swept volume 997 cm³
Maximum b.h.p. (gross) 41 at 5,000 r.p.m.
Maximum b.m.e.p. 131 lb/in²
Maximum torque 52·85 lb-ft at 2,700 r.p.m.
Compression ratio 8·9 : 1
Crankshaft Three-bearing, cast iron, hollow
Valves Overhead, vertical, push rod operated
Combustion chamber type Bath tub
Carburettor Solex 30 ZIC-2
Fuel pump AC mechanical
Dry weight 219·5 lb, including clutch

Transmission

Clutch Ford single dry plate, 7¼ in diameter
Gearbox type Four-speed, with synchromesh on second, third and fourth
Gear ratios

fourth	1 : 1
third	1·412 : 1
second	2·396 : 1
first	4·118 : 1
reverse	5·404 : 1

Dry weight 68 lb, including bell-housing
Propeller shaft Open, with needle roller bearing universal joints

Rear axle

Type Semi-floating, with hypoid-bevel reduction
Ratio 4·125 : 1

Suspension

Front Single transverse links, with anti-roll bar serving as radius arms; vertical telescopic members, embraced by coil springs and containing dampers
Rear Asymmetrical semi-elliptic springs, with lever type dampers

Steering

Make and type Burman recirculating-ball
Ratio 14 : 1
Turning circle 32 ft
Turns from lock to lock 2·62

Brakes

Front Girling hydraulic, with two leading shoes. Drum diameter, 8 in; shoe width, 1¼ in
Rear Girling hydraulic, with leading and trailing shoes; otherwise as at front. Mechanical actuation by hand brake
Distribution of braking effort

front	68 per cent
rear	32 per cent

Wheels and tyres

Wheel type Pressed-steel disc, with four-stud attachment
Tyre size 5·20-13 in, tubeless
Pressures, normally laden

front	22 lb/in²
rear	22 lb/in²

Dimensions

Wheelbase 7 ft 6¼ in
Track, front 3 ft 10 in
Track, rear 3 ft 9·8 in
Ground clearance 6·4 in
Overall length 12 ft 9¼ in
Overall width 4 ft 9·3 in
Overall height (laden) 4 ft 7 in
Kerb weight, with full fuel tank 1,625 lb
Frontal area 17·18 ft²

the periodicity, roll centre height and roll stiffness are 84 and 74 c/min, 9·35 and 3·17 in, and 100 and 178 lb-ft/deg.

A Burman recirculating-ball steering box, having a ratio of 14 : 1, is fitted to the Anglia. Between the drop arm and the slave lever of the steering linkage is a forged bar, and the arm and lever are connected to their respective swivel members by links of equal length. The Girling hydraulic brakes operate in 8 in diameter drums; they have a shoe width of 1¼ in and a total lining area of 76·8 in², or 106 in²/ton kerb weight.

Bracing of the steel floor of the underbody is effected by the propeller shaft tunnel, side members and cross members. To give increased rear seat width, the side members are carried over the top of the wheel arches. A detachable, fabricated cross member carries the front suspension and the front of the power unit, and another supports the unit behind the gearbox. The body is built as major sub-assemblies that are joined by external pinch-welded flanges, covered by finish mouldings. For the main body panels, 21 and 22 s.w.g. steel is used, whereas the stiffeners are mainly of 16 and 18 s.w.g. material.

It will be interesting to observe the reactions of the public to the rearwardly raked rear light, which has much to commend it. For a given height, it endows the rear seat passengers with the maximum headroom: the blending of the roof line into an orthodox forward inclined light notoriously results in some encroachment into this measurement. Although the overall height of the new Anglia is more than 2 in under that of the earlier model, the rear seat headroom is actually about 1½ in greater. The window itself, being flat, not only provides distortion-free vision but is also considerably cheaper to produce than a curved unit, particularly if of the double-curvature, wrap-round design. Again, the overhang of the roof shields the rear light from rain, snow or frost when the car is at rest, and screens the interior to a large extent from direct sunshine.

Two possible disadvantages of the reverse slope of the light are an increase in aerodynamic drag, and a greater tendency towards the deposition of road moisture and dirt flung up into the wake. However, it is claimed that the rear light is actually less prone than others to deposition, and according to the Ford technicians, wind tunnel tests have revealed that the new body lines result in a drag coefficient at least as good as that of a more conventional form. It is likely that the favourable front end design and gently falling roof line assist in this latter respect.

At the rear, the side members of the underbody are swept over the wheel arches, to give maximum rear seat width. The spare wheel is rather inaccessible with much luggage in the boot

Since the windscreen is of the single-curvature type, entrance to the front seats is unrestricted by the pillars, and the door width of 43 in results in easy access to the rear seat. The door lights retract completely, and the usual hinged ventilating panels have thief-proof catches. On the de luxe model, the quarter lights are hinged on their leading edges, to provide an additional means of ventilation.

The boot has a volume of 10 ft³, which is above average for a 1-litre car in this class, but the mounting of the spare wheel upright against the front wall must be criticised in respect of accessibility when luggage is carried. Although the depth of the skirt panel at the rear of the boot is sufficient to necessitate an appreciable lift during loading and unloading, the disadvantage is partially offset by the ample size of the opening. This is a secondary benefit derived from the rear light design, which permits the hinge line of the boot lid to be further forward than usual.

In its general styling, apart from the controversial question of the rear light, the body is attractive, and shows a marked advance. The bonnet line dips appreciably at the front, between the headlamps, and the frontal opening is shallow. On the de luxe version, the grille is reticular and of full width; its surrounding moulding tapers in depth towards its extremities, which embrace side lamps of approximately triangular shape. A similar surround and side lamp layout is employed on the standard model which, however, has a narrower opening with horizontal slats.

The headlamps have a rather protuberant mounting, and the peaks of the wings are extended to form cowls over the lamps. A gently falling and flared swaging on the side panels adds to the impression of length; it is accented on the de luxe car by a bright moulding that runs into chromium plated embellishments on the edges of the headlamp cowls. The slightly convex waistline is extended behind the rear light to form shallow tail fins, the peaks of which are visible from the driver's seat, as an aid to reversing.

A p.v.c. coated fabric is employed for the trim and head lining, also for the upholstery on the standard model. The de luxe Anglia, on the other hand, is offered with the choice of two-tone p.v.c. fabric, rayon cloth or, at extra cost, leather upholstery. Rubber matting comprises the floor covering. The instrument layout is neat and practical, and the panel is matched by a lockable glove compartment of similar shape on the other side of the facia; below there is a full-width parcels shelf. Fresh-air heating and demisting equipment is available as an extra.

The wheelbase is 3½ in longer than that of the previous Anglia, but the track has been reduced by approximately 2 in at both front and rear. These changes and the altered styling result in an increase of 3¾ in to the overall length, and a reduction in overall width of almost 3½ in. By virtue of improved use of the available space, however, the interior width is diminished by a smaller amount, while the longer wheelbase is used to provide a worthwhile amount of extra leg-room for the occupants of the rear seat. The ratio of wheelbase : mean track is 1·97 : 1, and those of wheelbase : overall length and mean track : overall width are respectively 0·589 : 1 and 0·802 : 1. Of the kerb weight quoted in the specification data, 53·5 per cent is carried by the front wheels.

After a production run of six years, the rather crude but robust Popular model has been discontinued. However, the name carries on, being now applied to a slightly modified version of the previous Anglia 100E, a two-door saloon that will be sold in standard form at under £500, inclusive of purchase tax. Although the actual figure is about £50 more than the cost of the old Popular, it is still lower than that of

any other full four-seat saloon sold in this country. This car retains the 1,172 cm³ side valve engine which, with a compression ratio of 7·0 : 1, has a power output of 36 b.h.p. at 4,500 r.p.m.; its maximum torque is 53 lb-ft at 2,500 r.p.m. As before, a three-speed gearbox is fitted.

Among the minor alterations is the restyling of the rear lamp groups. Both the standard and de luxe models have chromium plated bumpers, and the upholstery and headlining are of p.v.c. fabric. Additional features of the de luxe Popular are a bright metal instead of a painted radiator grille, also opening quarter lights, and chromium plated side mouldings and surrounds for the windscreen and rear light.

Ford's small car programme is completed by a modernized version of the four-door Prefect. The main difference between this car and its predecessor is that the new 997 cm³ engine, with its four-speed gearbox, is fitted in place of the 1,172 cm³ side valve unit. Improvements have been made to the seating, the upholstery materials of which are as for the latest Anglia. The door trim and upholstery have a two-tone finish. Other luxury details include fitted pile carpets, flexible sun visors, dual wind-tone horns, and additional ash trays, installed in the rear compartment.

Pressings and Castings

A NEW publication from the Copper Development Association is entitled *Hot Brass Pressings*. Hot pressing, as a method of production of components from brass and copper-base alloys is a relatively recent development, but it is rapidly gaining ground in a number of industries. The booklet has 66 pages, is well illustrated, and provides a considerable amount of useful information. Mention is made of the various stages of manufacture, the properties of the materials and the presses and tools employed; also, suitable applications for the method are indicated. Copies of the booklet are available from the Association, at 55, South Audley Street, London, W.1.

Another booklet of interest to engineers is *Casting Aluminium*, and it has been issued by the Reynolds Metal Company, Richmond 18, Virginia, U.S.A. It has 32 pages and covers features such as the casting processes suitable for aluminium, the various alloying elements and their effects, and the selection of an alloy for any particular purpose. There are sections, too, on the design of aluminium castings, the handling of the molten metal, and the trimming and cleaning of castings. Eight reference tables provide additional useful data. The booklet can be obtained from the Reynolds Metal Company, Dept. PRD-17, Box 2346, at the address already given.

New Hand Tachometer

TO SUPPLEMENT the existing range of four hand tachometers, Smiths Industrial Instrument Division has introduced a fifth model, known as the ATH.24. It is intended for use with machinery having a speed range of up to 4,000 r.p.m. The new instrument has three ranges—0 to 400, 0 to 2,000 and 0 to 4,000 r.p.m.—and the dual scale and figures are in black on a white ground. Supplied in a sturdy case, the ATH.24 tachometer set includes male and female rubber centres, an extension piece for the spindle, and a disc for the measurement of surface and cutting speeds. It is stated that a reading accuracy of $\pm\frac{1}{2}$ per cent is given, and that the unit is unaffected by position, humidity or temperature variations over a wide range. Enquiries should be addressed to the manufacturers, at Chronos Works, North Circular Road, London, N.W.2.

Packaging for Air Freight

TRANSPORT of goods by air is now commonplace but, because of special circumstances, some special thought needs to be given to their packaging. In order that these considerations may be brought to the notice of shippers, a new section, No. 20, of B.S.I's Packaging Code, B.S. 1133, has been prepared, largely at the request of the airlines. The new section, entitled "Packaging for air freight," gives in general terms guidance on the special considerations involved in packaging for air transport which, if followed, should greatly assist packers in avoiding wasted time and energy. Much financial loss caused through faulty packaging should also be prevented.

This new section of the code, which does not include provisions for livestock, gives valuable advice on variations of pressure and temperature, particularly important when packing liquids and gases. Other special considerations dealt with are factors to be taken into account because of the actual structure of the aircraft: for example, it may be necessary to break up bulky packages owing to the size of the aircraft door. Copies of this Standard can be obtained, price 4s. 6d. from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1. Postage will be charged extra to non-subscribers to the Institution.

Production Engineering

MANY opportunities exist nowadays for the young engineer to make his mark in production engineering. With a view to providing a guide to these opportunities, the Institution of Production Engineers has recently published an illustrated booklet, which will be of interest not only to boys leaving school and to their parents, but also to technical colleges, training officers and youth employment officers. The title of the booklet is *A Career in Production Engineering*, and copies are obtainable from the Institution, the address of which is 10 Chesterfield Street, London, W.1. Enquiries should be addressed to the Press Officer.

Albion Suspension Improvements

IMPROVED suspension systems can now be supplied by Albion Motors Ltd., for their Claymore and Chieftain commercial vehicle chassis. There are two, the first of which comprises two-stage helper springs, fitted to the rear Axle only. These springs are not intended to provide additional load-bearing ability; rather are they designed to reduce rolling on a vehicle with a relatively light body but a high centre of gravity when laden, such as a pantechnicon. Also, they usually provide a more comfortable ride in the unladen condition. These springs are standard on the Chieftain tipper model which, of course, is run either empty or with full load and a high centre of gravity.

Where a vehicle has a particularly heavy body, again with a high centre of gravity, the alternative, anti-roll springs are employed. These are stiffer units with a Fox type clip at the eye ends. Typical uses would be a high van body on the Claymore chassis, and a double-deck cattle body on the Chieftain. In these instances, the anti-roll springs would be fitted to both axles of the Claymore, but in the case of the Chieftain they would be fitted to the rear axle only.

FINE BORING AND FINE TURNING

Applications of Boneham and Turner Equipment Demonstrate Versatility of the Process in Production

FINE boring and fine turning are being used increasingly in production, due to the fact that components can consistently be finished to exceedingly close limits of accuracy. Essential requirements are a machine of exceptional rigidity; a very accurately mounted spindle running at optimum speed; a single-point, carbide-tipped or diamond tool; a fine and smooth table feed; and a light cut. Assuming all these features are provided in production equipment, components can be finished to limits of accuracy as close as 0·0002 in for size; to 0·0001 in straight or parallel; and within 0·000075 in for round. Combined with such accuracy, the surface finish can be down to 2 microinch average, according to the physical and mechanical properties of the metal being machined and the shape of the cutting tool employed.

Fine boring can be used with equal efficiency for mass or small-quantity production by varying the number of spindles and fixtures fitted to a standard machine. Also, several bores can be machined at the same setting in accurate relation with each other or in alignment by using groups of spindles mounted on fixed centre distances. Although primarily intended for light, accurate, finishing operations removing approximately 0·005 in to 0·030 in of material, quite heavy roughing cuts can be taken if necessary. Die-castings and shell-moulded castings, for example, can frequently be machined direct from the castings when limits are reasonable.

Further advantages, of substantial importance, obtain since fine-boring machines can be operated by unskilled labour and, due to the use of simple, single-point tools, setting is greatly simplified and running costs are reduced to a minimum. In total, fine boring gives results which can scarcely be obtained by any other method.

Fine-boring machines incorporating the required characteristics are built to exacting standards by Boneham and Turner Ltd., Nottingham Road, Mansfield, in single-end and double-end designs. Fig. 1 illustrates a double-end model in which spindles are mounted at each end of the machine. Two of the more important requirements of a fine-boring machine are a completely steady table feed and the maximum abstraction of generated heat from the machine. Generated heat can cause serious inaccuracies due to expansion and distortion of machine elements.

Boneham and Turner machines meet these specific requirements by using a mechanical screw feed to the table instead of what is today the more conventional hydraulic

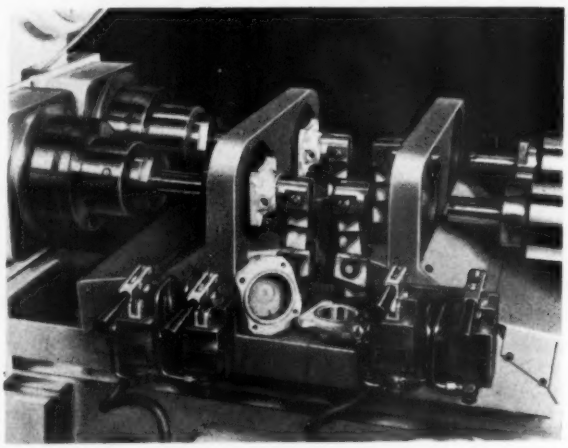


Fig. 2. Double-end machine fine-boring disc-brake cylinders to limits of 0·0005 in. Spindles are fitted with automatically retracting boring bars

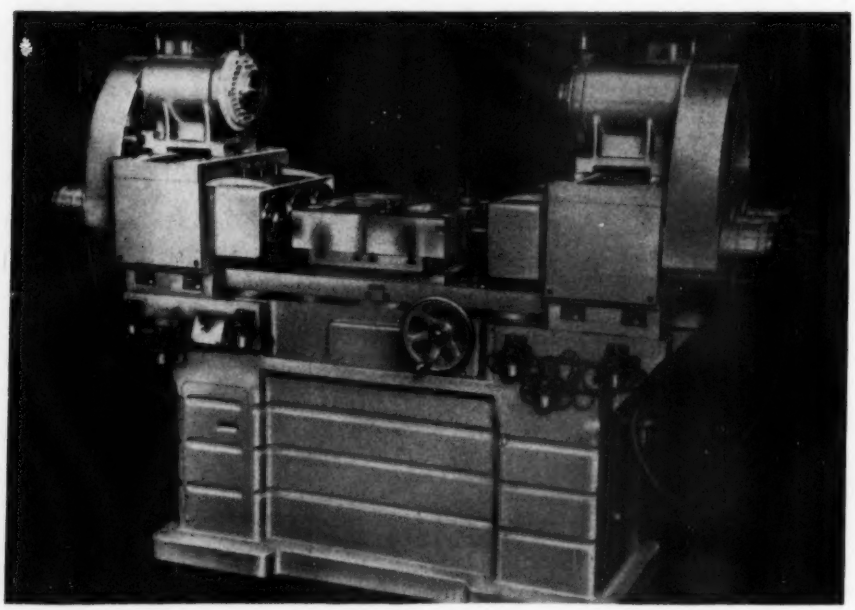


Fig. 1. Boneham and Turner double-end type fine-boring machine

actuation. This screw is of large diameter and is hardened and ground. The bronze feed nut is also of generous proportions and engages the feed screw without imposing any load on the table except for moving it forward. The life of these two components is almost indefinite.

With this method, an absolutely steady table feed can be guaranteed. In addition, the generated heat associated with hydraulic pumps and equipment is completely eliminated. Maintenance and setting is also greatly reduced. Only two cams need be modified to alter the position of the fine-feed engagement and disengagement.

To reduce the heat of the machine to a minimum, the spindle drive motors are mounted above the spindles on a bridge member, so that the heat from these motors rises above the machine instead of through it. This type of design also facilitates setting the spindles at an angle for taper-boring or taper-turning operations.

The fine-boring spindles are mounted on high-precision ball bearings, preloaded to remove all traces of radial or end clearances. The maximum run-out of the spindle flange and diameter is within 0·00005 in. Spindles are available in a wide range to suit various applications and with speeds up to 7,500 rev/min.

Fig. 2 shows a double-end fine-boring machine finish-boring disc-brake cylinders in malleable iron to limits of 0·0005 in. The component is located from an external spigot in a hardened bush. Whilst two components are being bored at one end of the fixture, the other end is unloaded and reloaded ready for operation. By using a range of interchangeable hardened bushes a number of different cylinders can be dealt with. The average floor-to-floor time for this operation is 20 seconds per component. A feature of the set-up is that the boring bars automatically retract at the end of the boring operation, thus eliminating the scratch line on rapid return and also increasing tool life.

In Fig. 3, a single-end fine-boring machine is shown boring bronze bushes in hardened gears. The bushes are bored concentric with the outside diameter within 0·001 in total indicator reading and to within 0·0005 in for size. Components are held in sliding-jaw chucks which are operated from air cylinders mounted at the rear of the spindles. The boring bars are pivoted and incorporate dial indicators so that the tools can readily be set to extremely close limits. The floor-to-floor time is 25 seconds per component.

A similar machine is used for boring hydraulic-brake cylinders. By using a range of interchangeable fixtures, both the drum cylinders and the master cylinders are bored on the same machine. Two components are machined simultaneously and these are clamped by an air cylinder operating floating vee-blocks. The floor-to-floor time averages 15 seconds per component.

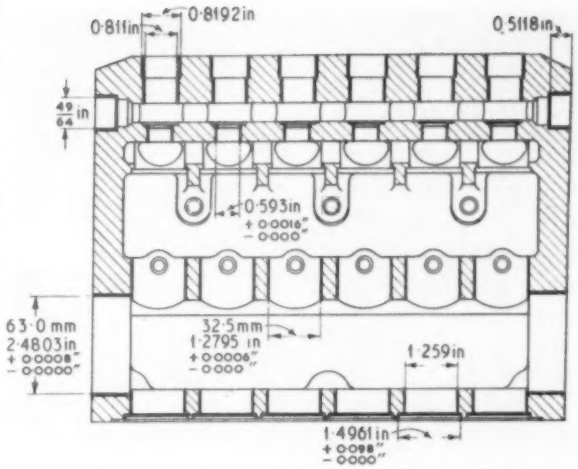


Fig. 5. Section of the six-cylinder diesel fuel injection pump body bored and faced on the double-end machine in Fig. 4

The double-end machine in Fig. 4 is equipped for boring diesel engine fuel-pump bodies. The machine bores six sets of equally spaced holes on 50 mm centres at each side of the component. The holes in one side each consist of three concentric bores of 24 mm, 20·8 mm, and 15·06 mm diameter with an adjoining face. At the other side, three concentric bores of 38 mm, 35 mm and 32·5 mm, also with an adjoining face, are dealt with.

Three spindles are fitted to each end of the machine and the component is held in a fixture on a central indexing table. After machining three bores at each side of the component, the table indexes so that three further holes at each side can be dealt with. By using interchangeable fixtures, three-cylinder and four-cylinder pump bodies can be dealt with in the same way. The line drawing, Fig. 5, gives dimensional details of the bores produced in this operation.

Fig. 3. Single-end fine-boring machine boring bronze bushes in gears to limits of 0·0005 in and concentric with outside diameter within 0·001 in

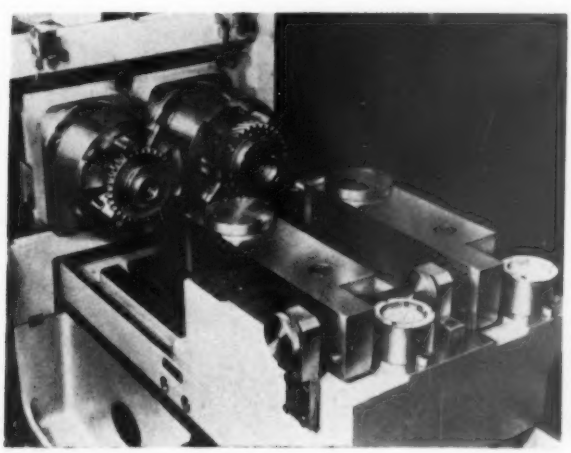
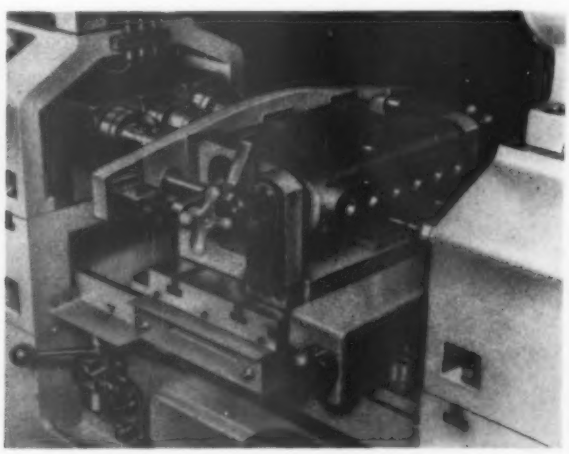


Fig. 4. Double-end machine boring a total of 36 holes and cutting 12 faces in diesel engine fuel-pump bodies of aluminium



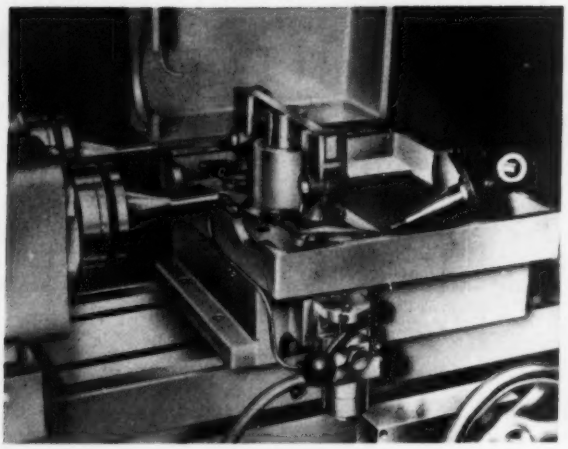


Fig. 6. Dual spindle, single-end machine boring the king-pin holes in steering knuckles to a tolerance of 0·001 in. Floor-to-floor time for this component is 35 seconds

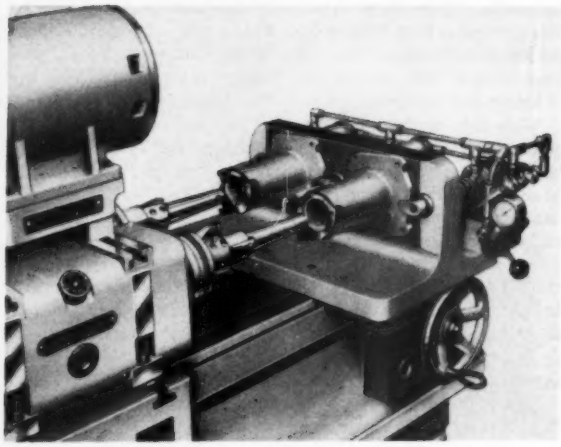


Fig. 7. Single-end machine for rough and finish boring of aluminium pump drive housings. First spindle carries out the roughing operation and the component is transferred to the second spindle for finishing

For finish-boring king-pin holes in steering knuckles a single-end machine set up as in Fig. 6 is used. The component material is high-tensile steel and the holes are held to 0·7315/0·7325 in diameter. The steering knuckles are set at an angle of 6½ deg, accurate in relation with the bearing diameters. Clamping equipment comprises an air cylinder which lifts and rotates pivoting vee-blocks clear of the component to facilitate loading and unloading. Coolant is supplied under high pressure in order to clear away chips and to give a good surface finish, with maximum tool life. The floor-to-floor time is 35 seconds per component.

Aluminium pump-drive housings for diesel engines are finish-bored and faced on a single-end machine, Fig. 7. It is fitted with two spindles, one for roughing and the other for finishing. After the roughing operation, the component is transferred to the finishing station and a further component loaded in the roughing position. In this way, one complete component is obtained at every cycle of the machine. The component is located from a spigot and is clamped by air-operated, pull-back fingers which rotate clear of the component to give access for loading and unloading. Of the three aligned bores, two of 1½ in diameter are held within limits of +0·001 in and −0·0005 in, and one of $2\frac{3}{16}$ in diameter to limits of +0·00125 in and −0·00075 in.

In Fig. 8 a similar machine is set up for boring axle tubes. The ball-bearing diameter and the oil-seal diameter are machined at the same setting. This fixture incorporates a sliding clamping member so that axle tubes of various lengths can be accommodated. Location is obtained from hardened steel bushes of various sizes, which are interchangeable to deal with different components. The floor-to-floor time is 40 seconds per component.

Sun-wheel blanks for a planetary gear unit are finish bored and faced on a single-end machine. The bore is held to limits of 0·0005 in and concentric with the outside diameter within 0·0002 in total indicator reading. The limits of accuracy for concentricity are obtained by using diaphragm chucks which are operated through the spindle centres by air cylinders. Diaphragm chucks will hold limits of concentricity within 0·0002 in providing the outside diameter of the work is previously finished to limits of approximately 0·0005 in. In this case, the components are centreless-ground to this limit before the fine-boring operation. The boring tools are mounted on a cross table

Fig. 8. Single-end fine borer finish-boring ball-bearing and oil-seal diameters in axle tubes. Air-operated clamping unit slides to handle tubes of different lengths. Floor-to-floor time 40 seconds

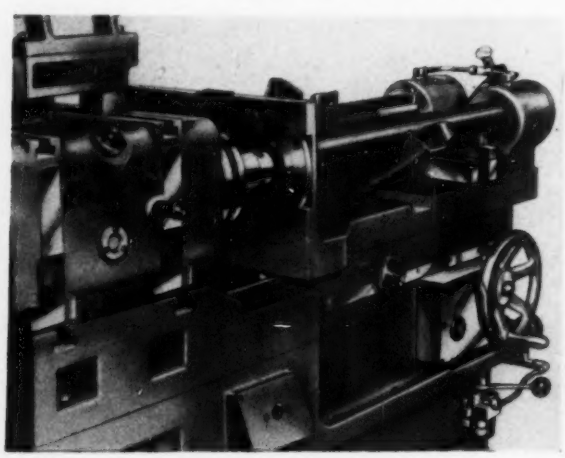
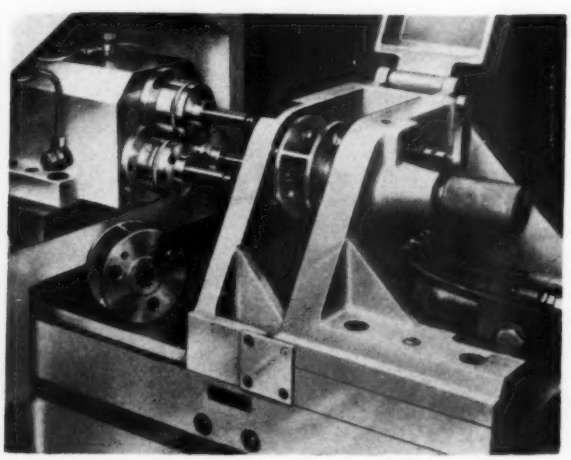


Fig. 9. Single-end machine fitted with cluster of three spindles boring three sets of holes in steel planet-gear carriers. Holes are held with a tolerance of 0·0005 in for position



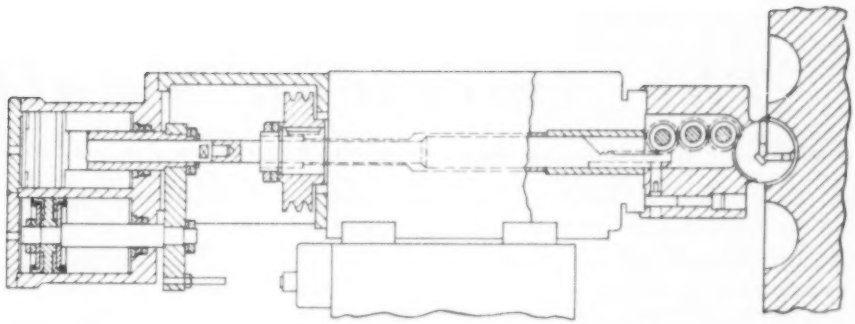


Fig. 13. Arrangement of spindle having a spherical boring head and a cylinder for rack-and-pinion actuation. Dual-spindle machine, indexes twice to form six hemispherical combustion chambers

which, after the boring operation, indexes to carry out the facing operation. The floor-to-floor time is 10 seconds per component.

The boring of three sets of equally pitched holes in steel planet carriers for an over-drive assembly is performed on a single-end machine set up as shown in Fig. 9. Bores are $\frac{9}{16}$ in diameter held to limits of $-0{\cdot}0005$ and $+0{\cdot}001$ in and are equally spaced on a 3·475 in diameter pitch circle to limits of $\pm 0{\cdot}00025$ in. The three sets of bores are machined simultaneously by a fine-boring spindle assembly consisting of three spindles in one housing. To prevent any possibility of inaccuracy due to expansion of the spindles they are air-mist lubricated so that their running temperature remains constant. The component is located by a hand-operated taper plunger in the central bore and radially from a further spring-loaded plunger in one of the previously drilled bores. Clamping is then effected by an air cylinder through a lever mechanism.

A double-end machine, Fig. 10, deals with shock absorber piston-rod guides from the die casting. The bores are held within a tolerance of 0·0003 in, with a surface finish of 8 micro-inches, and the outside diameter has a tolerance of 0·001 in. Also included in the operation is an undercut adjacent to the outside diameter.

This machine is fitted with six spindles, three at each end. Whilst three components are being machined at one end, the other end is unloaded and reloaded. The components are held in rotating collet-type chucks, operated by air cylinders through the spindle centres. Boring bars incorporate micrometer adjustment. The component is illustrated in Fig. 11, the diameters being dealt with are shown by heavy lines. Production is at the rate of 450 components per hour.

The dual-spindle, single-end machine, Fig. 12, was specially developed for finishing hemispherical combustion chambers in engine cylinder heads. The chambers are machined by a single-point tool which both revolves and rotates, thus generating a true hemisphere. The method of operation is shown in Fig. 13. Two chambers are machined at the same time, the main table being indexed twice to deal with six cavities. As the chambers are not equally spaced, one of the fine-boring units, complete with its motor drive, indexes laterally to compensate for the different spacing. The component material is cast iron and the floor-to-floor time is five minutes. This method ensures that true hemispheres are machined, each one being exactly the same to within fine limits, with a good surface finish that eliminates the need for any further operation.

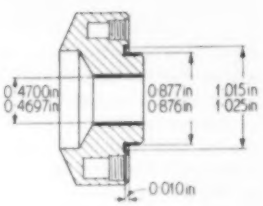


Fig. 11. Boring, turning, and undercutting operations on a die cast piston for telescopic shock absorbers. The set-up is shown in Fig. 10, below left

Fig. 10. Double-end borer machining shock absorber guide pistons from the die casting. Bores are held to a tolerance of 0·0003 in and an outside diameter to 0·001 in. Production 450 components per hour

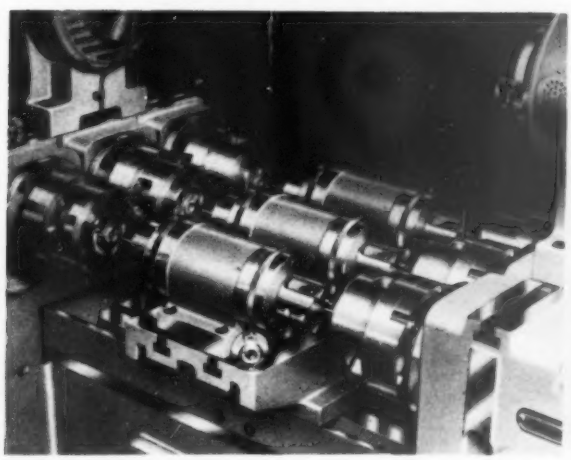
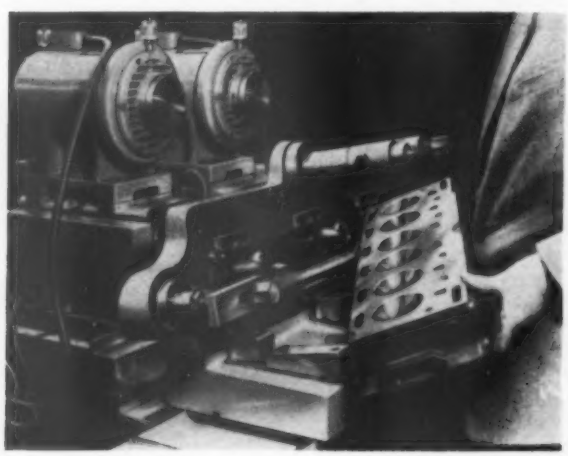


Fig. 12. Machining hemispherical combustion chambers in cast iron cylinder heads. Two chambers are machined simultaneously and the component is indexed twice for the six cavities. Floor-to-floor time 5 minutes



The American Small Cars

Preliminary Information on the Chrysler, Ford and General Motors Products Designed to Fill the Widespread Demand in the U.S.A. for More Compact Vehicles

IT has been known for some time that the big three motor manufacturing organizations in the U.S.A. were to produce for 1960 an additional range of cars considerably smaller than their current models. The success of the compact, and simple, American Motors Rambler and Studebaker Lark vehicles was an indication that, in the opinion of many buyers, Chrysler, Ford and General Motors had gone too far so far as size is concerned: their cars occupied too much road and parking space, and were too powerful and uneconomical for normal requirements. These latest smaller cars have been designed to compete with the Rambler and Lark in the changing market. The rather limited information so far available reveals that all three are roughly comparable in size with such cars as the Ford Zephyr and Vauxhall Cresta. Only in the case of the Chevrolet is there any large departure from American orthodoxy, other than the general adoption of unitary construction.

Chrysler Corporation's contribution to this new generation of American cars is the Plymouth Valiant. How much smaller this vehicle is than the hitherto typical transatlantic products is revealed by the wheelbase of only 8 ft 10½ in and the overall length of 15 ft 4 in. The overall width is 5 ft 10 in, and the laden height only 4 ft 6 in; the four-door saloon body can accommodate six people, and is said to have a luggage capacity of 25 ft³.

A 6-cylinder, overhead valve engine is employed. It has a bore of 86·3 mm and a stroke of 79·4 mm, giving a swept volume of 2,790 cm³, and is inclined at 30 deg to the vertical, to minimize the overall height. Wedge type combustion chambers are embodied in the aluminium cylinder head; the compression ratio is 8·5 : 1, which is appreciably lower than has recently been favoured in the U.S.A. Performance figures are not yet available, but the engine is claimed to have an output of 100 b.h.p. and a fuel consumption of about 25 m.p.g. in normal driving.

There is a choice of a three-speed gearbox, with baulk ring type synchromesh and manual control, or an automatic transmission. The latter is based on the Chrysler Torque Flite unit but is smaller and lighter. To keep weight down, extensive use is made of aluminium in both transmission systems. At the front, suspension is effected by means of a system of double transverse wishbones and torsion bars, and at the rear, the axle is mounted on asymmetrical leaf springs; in both cases, the spring action is controlled by telescopic dampers.

In addition to the saloon, two station wagons are manufactured differing in the seating accommodation and overall length. Bright anodized aluminium is employed for the radiator grille on all models, and another common feature is the use of paired headlamps. Both bumpers are of the wrap-round pattern, and the wheels are fully exposed by their openings. In general, the styling is good and the decoration restrained, but there is one concession to the gimmick complex: the boot lid of the saloon is embossed with a simulated spare wheel cover. P.v.c. material is employed for the upholstery and trim but, on the inside of the doors, it has an aluminized finish.

According to Chrysler International S.A., the Valiant will be assembled in Rotterdam, Holland, for the European market, in addition to the normal U.S.A. production. The Rotterdam plant was acquired last year from Nederlandse Kaiser-Frazer Fabriecken N.V., and it is expected that assembly work should begin there early next year.

The Ford Falcon has a wheelbase of 9 ft 1½ in, which is slightly longer than that of the Valiant, but its overall length is 2¾ in less; the overall width and height are almost identical with those of the Chrysler product. An admirable cleanliness of line has been attained and, here again, by current U.S.A. standards, the decoration is restrained. Unlike the Plymouth, the Falcon has only two headlamps, flanking a wide, low grille. Initially, only two-door and four-door saloons will be offered. The kerb weight is approximately 20½ cwt, which is less than two-thirds that of the 1959 Fairlane model.

Also a 6-cylinder in-line unit, the engine has a swept volume of 2,365 cm³. To keep the height down with an orthodox installation, it is considerably over-square, the bore being 88·9 mm and the stroke 63·5 mm. The overhead valves are inclined in bath tub type combustion chambers, and a single-choke downdraught carburettor is fitted. At 4,200 r.p.m., the engine is claimed to produce 90 b.h.p. gross, and its maximum torque is 138 lb-ft at 2,000 r.p.m.: this is equivalent to the high b.m.e.p. of 144 lb/in².

The three-speed gearbox has synchromesh on top and

With its two headlamps, clean lines and restrained decoration, the Ford Falcon has a notably European appearance. The power unit has a swept volume of 2·36 litres and develops 90 b.h.p. Unitary construction is employed and the car's length is 15 ft 1¼ in

second gears; the ratios are 1:1, 1·75:1 and 3·29:1, with a reverse of 4·45:1. A one-piece open propeller shaft transmits the drive to a hypoid-bevel live rear axle having a ratio of 3·10:1. An optional extra is the Fordomatic two-speed automatic transmission introduced last year. This has a torque converter giving a maximum multiplication of 2·4:1.

A double transverse wishbone layout has been adopted for the front suspension. The coil springs are mounted above the upper wishbones and embrace the telescopic dampers. Ball joints are used to connect the wishbones to the steering swivel members. The rear suspension is conventional, with almost flat, semi-elliptic springs and telescopic dampers, which are considerably inclined from the vertical. An unusual feature of the self-adjusting brakes is the use of composite iron and steel drums. The drum diameter is 9 in, and the total lining area should be adequate at 114·3 in^2.

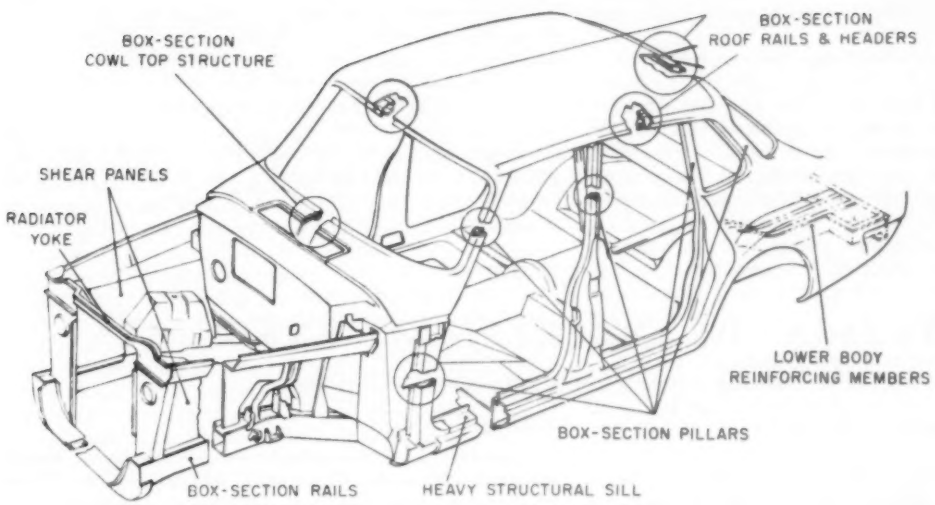
Certainly the least orthodox of the trio of newcomers is the Chevrolet Corvair, with which General Motors have broken much new ground. The outstanding departure from previous practice is the adoption of a rear engine mounting. Little less sensational, however, is the choice of engine type: it is a horizontally opposed, 6-cylinder unit with air cooling. Obviously, the installation problems are less with a flat engine of this size, 2·3 litres, than with an in-line unit, but the selection of air cooling is surprising in view of the American accent on quietness of performance. No doubt, however, the G.M. engineers have gone to considerable trouble to reduce noise and insulate the engine compartment.

The engine has a bore of 85·7 mm and a stroke of 66·0 mm, giving a swept volume of 2,296 cm^3. A six-throw crankshaft is carried by four bearings in an aluminium crankcase, the sump joint face of which is well below the shaft. A single, gear driven camshaft is employed; it lies below the crankshaft and actuates the push rods through the medium of hydraulic tappets. The valves are inclined in offset combustion chambers of combined bath tub and wedge form. Separate cylinder barrels of cast iron are employed, but there is a common aluminium alloy cylinder head for each bank of cylinders. It is stated that, because of the relatively low compression ratio of 8·0:1, the engine can be run on the American regular grade of petrol.

An unusual driving system has been evolved for the cooling fan, which is mounted on a vertical spindle above the crankcase and feeds air through ducting to the cylinder heads and barrels. To drive the fan, a crankshaft pulley and a single vee-belt of notched pattern are used. The run of the belt is changed from the vertical to the horizontal plane by the generator pulley on one side and an adjustable jockey pulley on the other. These are sufficiently remote from the crankshaft pulley to permit the belt to twist through the necessary 90 deg before its change of direction. The claimed power output of this interesting unit is 80 b.h.p. at 4,400 r.p.m., at which figure the mean piston speed is only just over 1,900 ft/min.

In its transmission layout, the Corvair resembles the Lloyd Arabella, described in the last month's issue of *Automobile Engineer*, in that the final-drive unit is sited between the engine and the gearbox. With the Chevrolet design,

The Chevrolet Corvair is more American in its styling than is the Falcon. Its rear mounted, horizontally opposed engine has six cylinders and is air cooled: the swept volume is 2·3 litres. Independent rear suspension, with long coil springs, is a feature



Details of the unitary construction employed on the Plymouth Valiant. This car has a larger engine than the other two: the swept volume is 2·8 litres. To keep the overall height to a minimum, the axes of the cylinders have an inclination of 30 deg to the vertical plane

The Corvair's roof forms a peak over the deeply curved rear light. There is little external evidence of the rear engine.

however, the pinion shaft of the final-drive unit is hollow and the gearbox input shaft runs within it. The standard gearbox has an aluminium casing and three forward ratios, with synchromesh on top and second. Its ratios are 1:1, 1·84:1 and 3·22:1, with a reverse of 3·64:1. As an optional extra, automatic transmissions is offered, embodying a torque converter with a maximum multiplication of 2·6:1. The standard ratio of the hypoid-bevel drive is 3·55:1, but a gear giving a ratio of 3·89:1 is optional with the manual gearbox.

Semi-trailing arms and coil springs are used for the independent rear suspension. The half shafts have Hooke's type universal joints at their inner ends only, and the pivot axis of each arm passes through the geometric centre of the joint. This layout was chosen, rather than the pure swing axle design, because it gives less change of camber angle with wheel travel, and bump deflection results in toe-in, thus partially counteracting the inherent over-steer of the 38:62 weight distribution.

At the front, the suspension is effected by means of transverse links and coil springs. The upper links are of wishbone type and have longitudinally inclined pivot axes to reduce dive, on braking; single-arm lower links, braced by radius rods, are employed. Both links are attached to their steering swivel by ball joints. A recirculating-ball type steering box, with a ratio of 18:1, is connected to a normal three-piece track rod assembly. The steering is said to be light and very precise, so that the gradual onset of oversteer, as the cornering force is increased, is easily countered. Because of the oversteer tendency, the nominal pressure of the front tyres is 11 lb/in^2 below that of the rear tyres. The 9 in diameter brake drums contain shoes of 1¼ in width, and 46 per cent of the braking effort is applied to the front wheels.

Orthodox unitary construction methods have been adopted for the body. At present, the only style is a four-door saloon which, if photographs are a reliable guide, rather lacks the cleanliness of appearance of the Ford Falcon. This impression is largely due to the heavy, raised moulding along the body sides; the moulding is a continuation of the cowl line over the paired headlamps, and it is carried through to a similar line at the rear.

The windscreen is well raked, as also is the rear light, which has considerable wrap-round. Supplementing the luggage compartment of about 9½ ft^3 volume, at the front, is a 4½ ft^3 space behind the rear seat squab. A fuel tank of 11 U.S. gal capacity is mounted between the toe board and the front suspension. The wheelbase of the Corvair is 9 ft 0 in and the track is 4 ft 6 in; for the overall length, width and height, the manufacturers quote dimensions of 15 ft 0 in, 5 ft 7 in and 4 ft 3¼ in. Among the optional equipment listed is an interesting heater, which utilizes the petrol from the main tank and is said to have a maximum consumption in the region of ¼ U.S. gal/hr.

INSTITUTION OF MECHANICAL ENGINEERS

Forthcoming Meetings of the Automobile Division

OCTOBER

London

Tuesday, 27th October, 6.00 p.m. at 1 Birdcage Walk, Westminster S.W.1. Paper: "Engineering Challenges to American Automotive and Petroleum Research", by Leonard Raymond, President, S.A.E., M.A.S.M.E.

Birmingham

Friday, 16th October, 6.30 p.m. at James Watt Memorial Institute, Great Charles Street, Birmingham. Paper: "Performance of Vehicles under Trans-Antarctic Conditions", by D. L. Pratt, M.A., A.M.I.Mech.E.

Derby

Monday, 19th October, 7.15 p.m. at Midland Hotel, Derby. Paper: "Adhesives in Engineering", by A. Bramley, B.Sc.

Scottish

Monday, 19th October, 7.30 p.m. at Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow. Automobile Division Chairman's Address entitled "Some Problems we Meet", by L. H. Dawtrey, M.I.Mech.E.

Western

Thursday, 29th October, 6.45 p.m. at Royal Hotel, Bristol. Automobile Division Chairman's Address entitled "Some Problems we Meet", by L. H. Dawtrey, M.I.Mech.E.

NOVEMBER

London

Tuesday, 10th November, 6.00 p.m. at 1 Birdcage Walk, Westminster, S.W.1. Two papers: "Vehicle Headlamp Beam Control", by K. R. Jones, and "Measurement of Driver Visibility and its Application to a Visibility Standard", by R. A. C. Fosberry, M.A., A.M.I.Mech.E., and B. C. Mills.

Coventry

Wednesday, 4th November, 7.15 p.m. in the Grosvenor Room, Hotel Leofric. Automobile Division Chairman's Address entitled "Some Problems we Meet", by L. H. Dawtrey, M.I.Mech.E.

North-Western

Tuesday, 3rd November, 7.15 p.m. at Crewe Arms Hotel, Crewe. Automobile Division Chairman's Address entitled "Some Problems we Meet", by L. H. Dawtrey, M.I.Mech.E.

SPRAY DEPOSITION OF METAL

Salvage of Production Rejects by the Sprabond Wire Process

J. ALAN SHEPPARD

METALLIZING was first introduced experimentally in 1912, but until the last war, apart from its use for the anti-corrosive coating of zinc and aluminium, it was seldom employed outside the maintenance shop. Four factors discouraged the use of the process in normal production, they are:

i. The inevitable slight loss of tensile strength occasioned by undercutting and rough-threading to provide a key for the deposit
ii. The potential hazard of a poor preparation concomitant with reliance on the human element
iii. The limitations introduced by rule of minimum coating thickness, dependent upon the diameter being built-up
iv. Cost.

The introduction in 1948 of the Sprabond Wire process obviated each of these disadvantages. This wire material, sprayed through a modern metallizing gun, will bond itself on to any metal provided it is clean and copper free. Moreover, there is no necessity for roughening to provide a key, nor is there any limitation as to thickness. Though the surface be as smooth as glass, an inseparable deposit can be made, at a commercially economical cost, without the introduction of heat.

Sprabond wire is essentially pure molybdenum, a metal with several unique characteristics. Its common oxide, MoO_3, is given off at 1,400 deg F and condenses as an easily visible smoke; therefore the metal particles are free of oxide when they strike the cleaned surface and, owing to their 4,750 deg F melting point, they alloy with the base-metal to a depth of about 0·0003 in.

Manufacturers, not unnaturally, first saw in the process a simple means of bonding any desired metal to a worn bore or shaft. A worn surface would be cleaned and a substrata deposit of under 0·002 in thickness of Sprabond applied before spraying on the required metal. The name describes its function, which is the formation of a sprayed bond between the base-metal and sprayed metal. Deposits of metals such as the stainless steels, nickel, aluminium and phosphor-bronzes, up to ½ in thick, are applied in this way.

Then phenomenal wear-resistance characteristics were found to have been obtained, and gave up to 25 times the normal journal life from parts running in bronzes or white metals. This is due to two main factors: first, the lubricant-absorbing surface-porosity inherent in all sprayed metal coatings, and secondly, the very hard particles of molybdenum, the pinnacles of which give a hardness reading between Rockwell C55 and C65. It was also found that the bearing life was increased.

Manufacturers were quick to see the advantage of a system whereby relatively inexpensive parts could be salvaged, frequently in seconds, economically and with complete confidence. Obviously, the more complex and expensive the part, the more interesting was the application. The motor car industry is a typical example. After detailed investigation, applications, which one or more of the limitations of standard metallizing had previously precluded, were now introduced. New procedures for production salvage were drawn up and the beginnings of an annually extending programme were involved. The following are from the list of automobile, truck and tractor parts currently salvaged by the Sprabond Wire process in a leading manufacturer's works.

Transmission shaft bearing, the fit of it in the gearbox
Axle end of the flange for the universal joint on the propeller shaft
Crown wheel spigot
Crankshafts: oil seal areas, flywheel spigot, and pulley shaft diameters
Front stub axle, wheel bearing journals
Camshafts.

At least one manufacturer, to facilitate standardization, demands that all overmachined diameters be reduced to specified under-sizes before submission to the metallizing department, which also deals with worn components from engines returned for servicing. In the manufacture of electric motors, bad fits between shafts and ball-ends are made good for a few pence, and it is difficult for even the most expert eye to detect which surface has the hard wearing molybdenum coating. Further, the virtually cold application eliminates risk of distortion of the shafts or harm to the windings. A typical cost comparison is that, recently evaluated, between the salvage of 72 undersize electric motor shafts by arc-weld and the Sprabond Wire process:

Arc-weld	£142
Sprabond Wire process	£24
Saving	£118

Vauxhall Motors Ltd., at Luton, originally installed Metco metal spraying equipment to coat wooden models in their styling department. That was early in 1940. The machinery maintenance division adopted the process in 1949 for the reclamation of components such as worn rams, spindles, and machine tool beds; and in 1954, the production salvage department introduced their first metallizing gun. The process has been approved for applications such as gear bevel pinions, crankshafts, and cams, a ⅛ in diameter wire being used. In this department, the costs in respect of one metallizing gun were recorded, and during the first eleven months of 1957, a nett saving of over £5,000 was effected.

Reclamation of hypoid spiral bevel pinions for a heavy lorry, made by another well-known vehicle manufacturer, is a typical example in respect of costing. The part is machined from a nickel chrome molybdenum forging. Although it may only be ground undersize by 0·003 in on the bearing diameter, it is reduced to a total of 0·012 in undersize, for standardization. About 0·010 in thickness of Sprabond is then applied over the 0·9548 in diameter, on a 1 in length. The total cost of materials is under one shilling and the metallizing time per pinion is about eight seconds.

Current developments suggest that, in the future, the process will be increasingly considered in design. Dynamometer tests of crankshafts, built up in this way on their main journals and crankpins, are confirming the reliability of the coating. Field tests of other wearing surfaces promise early introduction of the process on new parts. Electronically controlled equipment can be employed to give completely automatic application. One of the most interesting projects now on the drawing boards and under development is the all-aluminium engine, where molybdenum sprayed liners, giving excellent wear resistance, contribute to the lightness of the unit. Other likely applications for the process include V-belt pulleys, brake drums, ways for machine tools, cylinder walls in hydraulic equipment, and certain clutch plates.

SEALING CASTINGS

Ray-Heet Continuous-flow Plant, Installed in the New Ford Foundry, for Painting Castings for the Engine and Transmission Units of all Classes of Vehicles

A SIGNIFICANT addition to the equipment of the new Thames Foundry of the Ford Motor Co. Ltd. at Dagenham*, is a continuous-flow castings sealer installation. Designed and built by Ray-Heet (Process Plant) Ltd. of Great Bookham, Surrey, this fully mechanized dip-painting plant is the largest of its type in the United Kingdom. It has recently been brought into operation and is now integrated in the main production line in the foundry.

Due to the interrupted character of a cast iron surface, arising from the relatively soft graphitic inclusions in the metal structure, minute particles of mould sand, core sand, abrasive or metallic fettling dust, or other foreign matter may become entrapped.

In spite of most comprehensive routines of cleaning, vibrating, air-blowing, vacuum extraction, and washing, the dislodgement and removal of all such matter cannot be completely assured. Some may be retained in the interior surface of a casting when finally assembled and eventually be released when the engine or transmission unit of which it forms part is in service. It may then be picked up and possibly distributed by one of the respective fluid systems—lubrication oil, hydraulic fluid, or coolant—with deleterious effect.

As is implied by the designation, the function of this painting plant is to seal all such retained particles of foreign matter permanently in the castings. Thus, their release under the influence of temperature and pressure changes, thermal expansion and contraction of the metal, washing by fluids, or vibration is precluded. While sealing is the main function of the plant, its use confers other, incidental advantages. It prevents rusting, improves the efficiency of washing processes during or after machining, and provides a good primer coat for subsequent painting operations. Further, it improves working conditions in the machine shop since operatives are required to handle only clean, painted workpieces.

The plant occupies an area of nearly 12,000 ft², the major overall dimensions being 130 ft long and 90 ft wide. It comprises a cellulose paint dipping and draining plant, and a steam-heated drying oven for the castings, together with a hot caustic tank and hot and cold spray booths for cleaning the sling hooks. All this equipment is connected and traversed by a single, 6 in pitch, heavy-duty, overhead, monorail conveyor of some 900 ft in length.

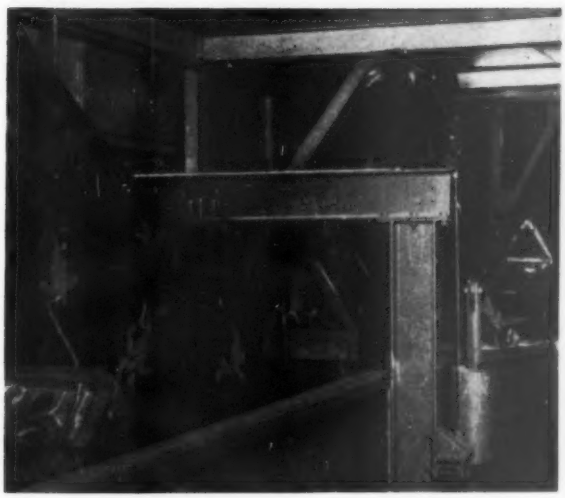
Interior view of the drying oven showing some of the heater batteries

Painting plant

Load-carrying trolleys, of the two-wheel, ball-bearing type, are pitched 2 ft apart on the chain and can each support

* *Automobile Engineer, June* 1958.

Castings are loaded on to the conveyor by gantry hoists. Maximum throughput of the plant is 47 tons of castings per hour



Castings traversing the dip tank in the painting and draining enclosure

Off-loading sealed castings. The conveyor travels at 16 ft per minute

a load of 220 lb. With the conveyor running at a constant speed of 16 ft/min and loaded to maximum capacity, the plant can process castings at the rate of 47 tons per hour. Currently, it is being operated, on two shifts, for 16 hours per day.

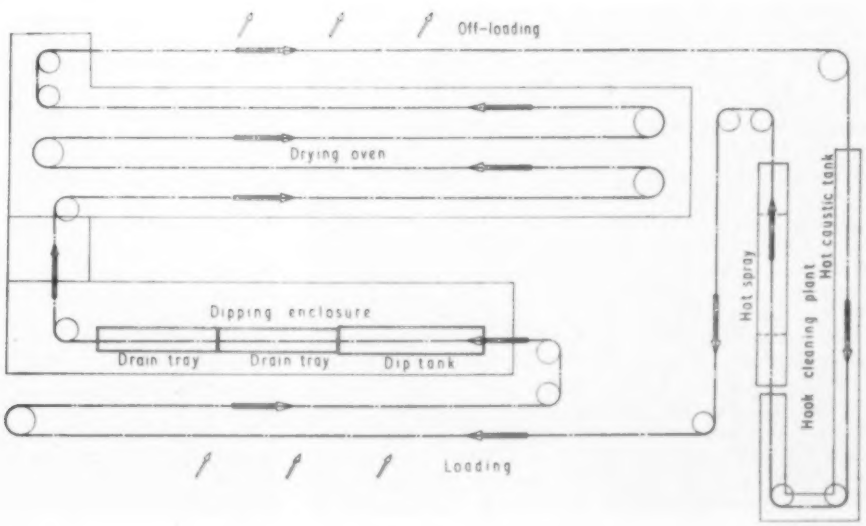
Castings are loaded on to a full-length run of the conveyor, arranged alongside the dip plant and having completely open access. The track loops back and then turns through 180 deg to enter the dip enclosure. Here the castings are lowered into the dip tank holding about 1,000 gallons of special sealing cellulose. This tank is punt-shaped, with overall dimensions of 19 ft 2 in long and 3 ft 6 in wide. Maximum depth is 3 ft 2½ in and the operational level is maintained at 2 ft 10 in by circulating the paint over a fixed weir. Circulation of the paint is by one of a pair of slow-speed Douglas 1¼ in diameter pumps, one being connected as a stand-by. Each pump is driven by a ¾ h.p. flameproof motor. Surplus paint is contained in a supply tank under the weir.

Following the dip tank are two long drip trays, each furnished with a sump with a piped connection to the jettison pit. This pit normally holds in circulation sufficient paint for one day's consumption, approximately 200 gallons, and is replenished daily. A small quantity of paint is fed to each tray from the main pump to maintain circulation and "carry-away" of paint drips. Paint in circulation is continuously filtered in duplicated 15 in diameter × 3 ft 6 in Vokes units of the gauze strainer type.

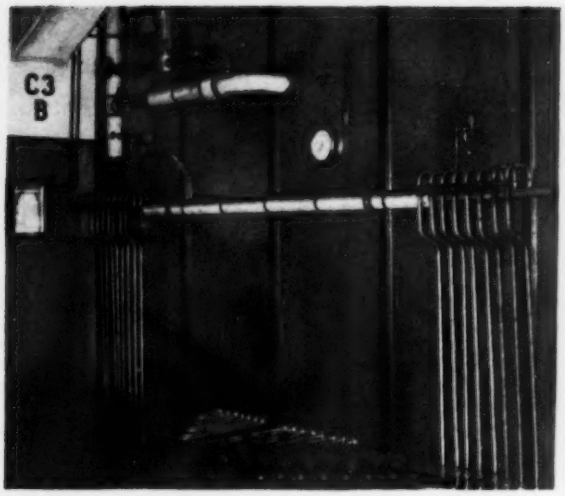
In the event of fire, the cellulose in the dip and supply tanks can be rapidly dumped into a sealed and vented jettison pit below floor level. A standard, 6 in diameter Ray-Heet dump valve in the floor of the dip tank is operated automatically in emergency by a pressure trip device in the CO_2 fire-suppression installation. The whole of the dip and drip equipment is enclosed in industrial partitioning, glazed from 3 ft 6 in to 7 ft levels. Four explosion panels are fitted to the roof and the enclosure is illuminated by four G.E.C. 4 ft, twin-tube, sealed fluorescent light fittings.

Drying oven

On leaving the paint plant the conveyor turns 180 deg to enter the drying oven, which is 89 ft long, 17 ft wide, and



Layout and flow diagram of casting sealing plant and sling-hook cleaning plant



One of the control points outside the large, steam-heated drying oven

Fully enclosed, steam-heated caustic tank in the sling-hook cleaning plant

9 ft 3 in high. The skin is built of standard panels over a steel-framed structure that also carries the conveyor monorail. Each panel, 2 in thick, comprises an inner and an outer metal sheet braced by internal struts, and sandwiching 2 in thick insulating material. At the entry and exit of the oven, profile heat traps are provided to minimize the loss of heated air.

Thirty-two tubular steam batteries are employed to heat the oven. Each battery is a welded construction of two 5 in diameter, plain tube, vertical headers and five 4 in diameter, horizontal, gilled tubes. The gills, arranged at $\frac{5}{16}$ in pitch, are $6\frac{1}{2}$ in diameter. Average length is 13 ft, providing a total length of 2,080 ft. By keeping the batteries reasonably short it is possible to accommodate the lineal expansion and contraction, about $\frac{3}{4}$ in, which occurs when heating up and cooling down.

Connections for the steam inlet and the condense outlet are arranged on one vertical header, which is rigidly bolted to the floor. The battery is allowed to expand away from this anchor point; the base flange of the other header is fitted with three $\frac{3}{4}$ in diameter steel balls which can run freely on steel track plates bolted to the floor of the oven. Additionally, each battery is braced to the main framework.

Unsuperheated steam is supplied at a pressure of 80 lb/in² and the approximate rate of consumption in 3,300 lb of steam per hour at the maximum throughput of 47 tons of castings per hour. With the conveyor running at a speed of 16 ft/min the stoving time is 21 minutes. Oven air temperature is maintained at 180 deg F and sheet metal deflector plates are fitted over the heater batteries to direct the air flow. A Spirax Ogden automatic steam pump lifts the total condense up to the condense return main.

To provide adequate temperature control the oven is divided into two zones, each under independent thermostatic control. The thermostats are sited within the oven and are connected to steam modulating valves. Dial thermometers fixed along the oven indicate the temperature in the two heating zones. For the complete oven, an indicating and chart-recording thermometer complete with two thermocouples, one in each zone, is provided.

After making four traverses of the drying oven, the castings are carried to an open-access, full-length run alongside the oven and off-loaded. As on the loading run, electrically operated gantry hoists are employed to lift and transfer the castings.

Hook cleaning plant

After off-loading the castings, the sling hooks, suspension jigs, and the baskets for small components remain on the conveyor and are carried to a cleaning plant for the routine removal of paint accumulations. Here they are passed successively through a hot caustic soda bath, a hot-water spray zone, and a cold-water spray zone. The caustic tank, U-shaped in plan, is approximately 70 ft long, 2 ft 9 in wide and 3 ft 3 in deep. With the liquid level at 3 ft the capacity is 3,600 gallons.

Steam heating is also employed for this unit, the liquid being maintained at a running temperature of 200 deg F by means of $1\frac{1}{4}$ in diameter steam coils mounted along one side of the tank and suitably protected from damage by traversing hooks or jigs. Each coil is arranged for easy withdrawal for cleaning and maintenance. Steam is supplied at a pressure of 80 lb/in² and the consumption rate is approximately 500 lb per hour. Effective soaking time for the sling hooks, with the conveyor running at 16 ft/min, is about three minutes. Steam coils are thermostatically controlled and two dial-indicating thermometers are fitted. The caustic tank is fully enclosed by a continuous extraction hood.

Immediately following the caustic tank is a tunnel enclosing the hot-water and cold-water spraying and draining zones. Overall dimensions of the tunnel are 33 ft long, 3 ft 6 in wide, and 9 ft 6 in high, the spray zones being 8 ft long in each case. At the normal speed of operation, the draining period is sufficient to avoid carry-over and intermixing of the two washes.

In the hot zone, water at a temperature of 200 deg F is delivered to the spray headers, from a collection tank, insulated by a 2 in layer of glass silk, by a Worthington-Simpson centrifugal pump at a rate of 100 gal/min. Paint on the hooks and jigs, softened in the caustic soda bath, is detached by the sprays and carried down to the tank, where it is trapped at weir bulkheads. Paint sludge is separated out from the water by means of three submerged filter baskets. Arranged for easy removal and cleaning, each filter is a galvanized sheet metal box having a wire-mesh top and bottom and packed with wood-wool as a filter medium.

The water, delivered by the pump at a pressure of 60 lb/in², is raised to operating temperature by steam-heated injectors controlled by a thermostatic valve in the main steam supply. To obviate heat loss, the pipework to the spray jet headers

inside the tunnel is insulated with glass silk. Masking shields fitted closely adjacent to the conveyor mechanism minimize the amount of spray fluid reaching the track, chain, and carriages.

For the cold spray, the foregoing installation is repeated with, of course, the omission of the heating system and the insulation for the tank and pipework. When washing and draining is completed the conveyor leaves the tunnel and turns into the loading run to recommence the circuit.

Ventilation

Comprehensive arrangements have been made for the ventilation of the complete plant. Actually there are four independent systems for specific duties.

1. To extract cold cellulose fumes from the dip plant and the paint store.
2. To extract hot waste air and cellulose fumes from the drying oven.
3. To extract steam vapour and caustic fumes from the hook cleaning plant.
4. To supply fresh air make-up to the three foregoing systems and to avoid raising the ambient shop temperature.

For the three extraction systems, Keith Blackman AFX fans of the axial-flow, belt-driven type are employed. Data relating to the fans follows:

1. Paint fume system. 27 in diameter, driven at 1,600 rev/min by 4 h.p. motor. Extracting 7,400 ft³/min against 1·5 in s.w.g.
2. Oven exhaust system. 21 in diameter, driven at 1,860 rev/min by 1·5 h.p. motor. Extracting 4,000 ft³/min against 1·25 in s.w.g.
3. Caustic fume system. 30 in diameter, driven at 1,425 rev/min by 5 h.p. motor. Extracting 7,250 ft³/min against 1·25 in s.w.g.

Impellers are integral castings of hub and aerofoil-section blades in aluminium-silicon alloy, except in the case of the caustic fume unit. Since aluminium will not withstand caustic fumes, this unit is fitted with a special impeller in mild steel and painted with two coats of alkali-resistant paint.

Discharge ducts for the three extraction systems are passed through the foundry wall and terminate at a height of 17 ft 6 in above ground level. The inlet duct for the make-up system is similarly taken outside the shop and is carried up to a height of 25 ft above the ground.

The plant processes castings for the engine and transmission units for all types of vehicles—automobiles, commercial vehicles, and agricultural tractors. With the exception of manual loading and off-loading, and the routine cleaning of filters, it is fully automatic in operation.

Profile and Helix Gear Tester

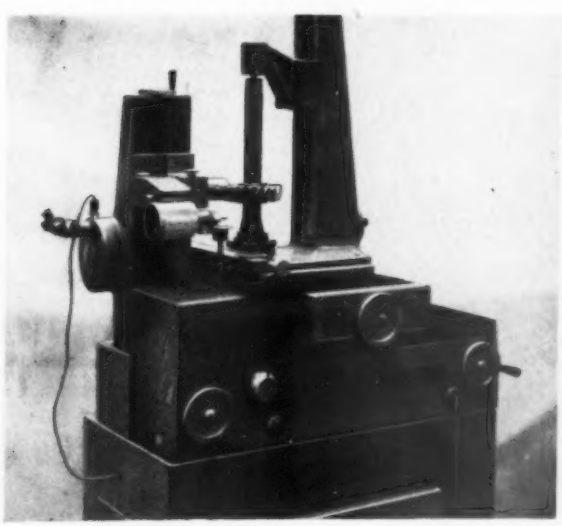
WITH experience in the manufacture of gears of every type extending over a hundred years, David Brown Industries Ltd., of Huddersfield, has necessarily been continually concerned in the development of gear testing and measuring equipment. Designed primarily for its own use, certain of these instruments have, from time to time, been made available for general sale by the Company's Tool Division. The latest of these is the No. 18 combined profile and helix tester provided with an integral graphic recorder which, when used for a batch or over a period, forms a reliable reference for quality maintenance.

This instrument will accept bored spur or helical gears up to 1¼ in circular pitch (10 mm module) with base circle diameters from ⅞ in (22 mm) to 18 in (457 mm). The centre locating attachment will admit a maximum diameter of 9½ in (240 mm) with 18 in (457 mm) between the centres. Maximum length of traverse along the helix is 6 in (152 mm). The graphic recorder gives a magnification of 500:1 and a range of 0·004 in (0·1 mm). The stylus can be loaded to operate on either flank of the gear under test.

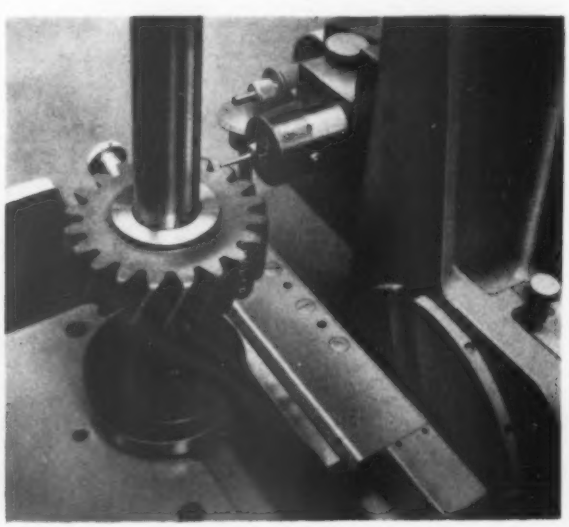
Involute testing is a simple operation. The base disc is brought into contact with the straight edge and, as the cross slide is traversed and the gear rotates, the stylus follows the base tangent until the tip of the tooth has been reached. If the flank is a true involute, a straight-line graph will be produced whilst, if any predetermined tip relief is specified, this will be accurately recorded.

Helix testing is achieved by means of a sine bar mechanism coupled to the straight edge. The sine bar is set to the required angle by a microscope with an illuminated glass scale. Operation requires merely the vertical traversing of the slide. The sine bar causes the gear to rotate, thus keeping the stylus in contact with the tooth flank. If the helix angle is correct the graph will record a straight line.

David Brown No. 18 profile and helix recording tester



The instrument set up for helix testing



Honing Developments

Automatic Machines Suitable for Incorporation in Transfer-type Production Lines Enable Economies to be Made in Finishing Operations

HONING techniques have developed rapidly in recent years and the process is accepted for finishing operations in the production of a wide variety of parts. Enhanced accuracy and surface finish can be secured consistently at a high rate of production and substantial economies can be made in grinding and other pre-finishing operations. As with other processes, batch size is an important consideration in the economics of production. The capacity and adjustability of the honing machine, however, usually makes it possible to use a single type of machine for a range of components of different size and shape.

There is a discernible trend towards the automatic handling of batches smaller than was considered hitherto to be practical. The more recently developed automatic honing machines can, in many cases, provide an economic solution to this particular problem. Methods of loading will necessarily be determined by the size and form of the component to be processed. Should the honing machine be used as a separate unit, it may be loaded by the operator tending the previous machining unit; the transfer and locating of the components for honing then being effected within the honing machine itself. By a suitable arrangement of various operations it is frequently possible for a single operator to tend several machines.

If the honing machine is included in a transfer line, the workpiece may be ejected from the previous station and transferred to the honing station on a roller track or a slide. Apart from the usual considerations of size and form of the component, the accuracy required may influence the method of loading. Where bores of extreme precision are necessary, it is frequently more economical to install only semi-automatic machines and to load by hand.

In all honing operations, automatic sizing of the bore is of paramount importance. By operating to an accuracy of between 0·0001 in to 0·0002 in and stopping the machine immediately the required dimension is reached, automatic sizing attachments have made automatic honing possible and practical. The following representative production examples are all currently running on machines built by Nagel G.m.b.H. of Nürtingen, Germany. Wickman Ltd., Banner Lane, Tile Hill, Coventry, are the agents for Nagel machines in the United Kingdom.

Cylinder blocks

For this six-cylinder block, with bores 80 mm diameter and 144 mm deep, the machine shown in Fig. 1 was specially developed. It comprises three separate honing units and is provided with suitable transfer equipment that enables the set-up to be changed, without undue difficulty, to accommodate different components. As six bores are honed by only three spindles, the transfer mechanism is arranged to give alternate short and long strokes.

The cylinder blocks are taken over automatically from the previous machine in the production line and are carried into the first station, where bores Nos. 1 and 2 are honed. When bore No. 1 has been completed, the transfer equipment strokes only a short distance to bring the neighbouring bore to the honing spindle. When bore No. 2 has been completed, a long transfer stroke carries the block into the second station for honing bores Nos. 3 and 4 on the same principle. This process is repeated to hone the last two bores at the third station. All spindles operate simultaneously, each working in a different component at any time. As each honing unit is equipped with an automatic sizing attachment, all bores are finished with accuracy.

Cycle time of this machine is approximately two minutes,

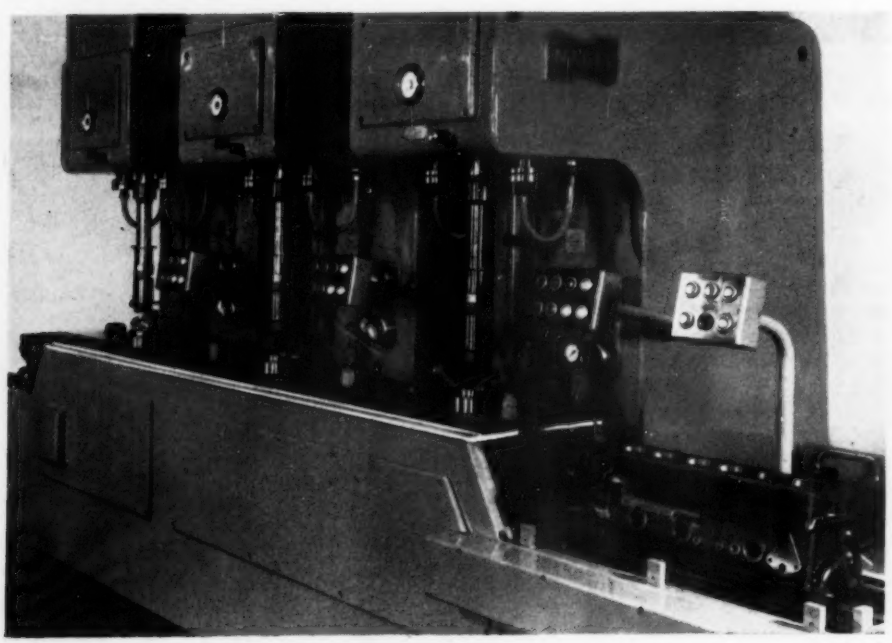


Fig. 1. Fully automatic, three-spindle machine equipped with indexing transfer mechanism for honing six bores in an engine cylinder block

Fig. 2. Super-finishing brake drums on a short-stroking machine

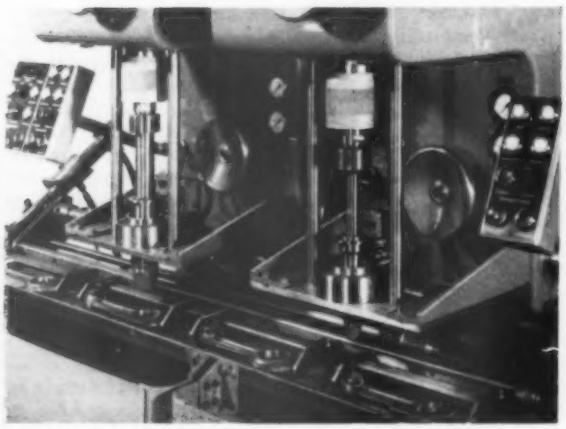


Fig. 3. Automatic machine for honing both bores in connecting rods

and the material removal from each bore is from 0·001 in to 0·0015 in. Special diamond honing tools are used, which have a working life of 30,000 bores. These tools make it possible to obtain accurately parallel bores with little over-run at the end of the honing stroke.

Brake drums

The super-finishing of brake drums has been carried out for a number of years on automatic honing machines. Fig. 2 shows a short-stroking machine with a newly developed sorting attachment with lever-type stop. This improves the flow of the components through the machine. In approximately 10 to 15 seconds the brake face, 210 mm diameter in this instance, is given a finish of approximately 25 micro-inches. In spite of the short honing time, the boring machine preceding this operation can be used with a feed of 0·012 in/rev.

Connecting rods

A two-spindle machine, Fig. 3, hones connecting rods in both big-end and small-end bores of 63 mm diameter and 35 mm diameter respectively. Either larger or smaller rods can be handled by changing the locating fixtures on the transfer mechanism. The two spindles are independent and the machine operates on a fully automatic cycle.

Centre distance of the bores cannot be affected since at each station the component is permitted to float in its location. Employing short-stroke honing, the material removed is from 0·0015 in to 0·0025 in. Cycle time ranges from 25 to 30 seconds.

Small connecting rods are commonly required in great numbers produced at a high rate. A suitable honing machine, Fig. 4, to handle such components has been highly automated. The machine uses a short-stroking attachment and is equipped for magazine loading. Only the big-end

Fig. 4. Magazine-feeding, short-stroking machine for honing the big-end bores only in small connecting rods. Output is 200 rods per hour

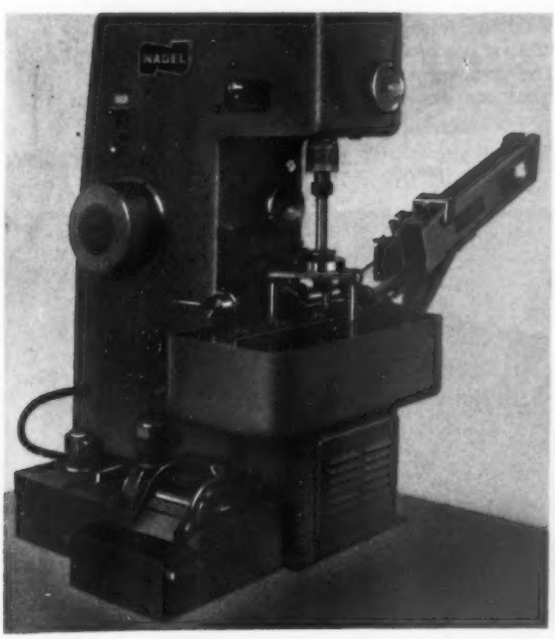


Fig. 5. This transfer machine pressure-tests, sorts, drills, hones, and gauges brake master cylinders. Floor-to-floor time is 30 seconds

bore, of 54 mm diameter in the example shown, is treated.

Each connecting rod is honed separately. Coming from the previous operation in the line, the components are loaded into the inclined magazine from where they are transferred automatically into the honing station. During the honing operation the component is allowed to float in its location and the machine is controlled by an automatic sizing attachment. A difference between individual components in the amount of material to be removed, up to 0·002 in, has no influence as the sizing attachment stops the machine only when the finished dimension has been reached. The accuracy of the sizing attachment is approximately 0·0001 in to 0·0002 in. The output of this machine is 200 rods per hour.

Automatic machines for small components

In the motor industry very large numbers of certain of the smaller components are needed, and to meet such requirements fully automatic honing machines, incorporating gauging and sorting stations, have been developed. In numerous instances these machines are included in an automatic transfer line. Typical components in this category are differential bevel pinions and engine valve rocker levers.

On these machines only undersize bores are honed, and the outstanding features are the gauging and sorting operations. One production example relates to bevel pinions having a bore 16·1 mm diameter and 21·5 mm deep. The parts are tipped into the magazine of the machine, a sorting plate aligns the pinions and carries them through a loading attachment into the fixtures on an indexing rotary table. On the table, the part is first brought to a station where the bore is gauged. Any component in which the bore, owing to heat stresses, is already oversize, is ejected at this station. At station 2 a component with a bore within the permissible tolerance is sorted out.

A component with an undersize bore is automatically transferred to the honing station, where it is brought to size in a floating location. The honed part is passed through the gauging station again, so that only components with the correct tolerance leave the machine. Undersize components comprise approximately 20 per cent of the total number arriving on the machine. The output is approximately 8,000 pinions in a two-shift day of 16 hours. Gauging time is 3 seconds and the honing time approximately 10 seconds.

Another, similar machine has been designed to deal with valve rocker levers on the same principle. In this case, however, the parts are loaded into the fixtures on the table, from where they are automatically brought into the gauging and sorting stations. Only from 5 to 10 per cent of all components arriving on the machine need honing and, therefore, the output is 15,000 parts in 16 hours.

Brake cylinders

The special transfer machine shown in Fig. 5 was developed for processing a brake master cylinder. This machine has nine stations, on which twelve operations are carried out, including pressure-testing, sorting, drilling, honing and gauging. The blind bore of the high-pressure cylinder, 25·44 mm diameter and 129 mm deep, is honed in two operations. Rough honing is controlled by an automatic sizing attachment, while at the finish-honing station an automatic timer controls the finish polishing of the surface. The completed component is ejected at the end of the line and the floor-to-floor time is 30 seconds.

A machine of a type adaptable for a variety of small components is used for honing a through bore, 25·31 mm diameter and 67·8 mm deep, in wheel brake cylinders. The tolerance on the bore is 0·03 mm. Components are loaded on to a transfer conveyor by the operator of the previous machine in the line, and the conveyor carries them to the honing station. During the honing operation the component is allowed to float.

Material removal is approximately 0·004 in on the diameter and the honing time is 15 to 20 seconds. The operation is controlled by an automatic sizing attachment and on completion the component is carried to the end of the conveyor and is automatically ejected. The set-up is shown in Fig. 6.

Bearing races and bearing seats

For this type of component, automatic honing machines have been developed which have proved very successful during the relatively short period they have been used. Fig. 7 shows the operational field of a honing machine equipped with a four-station indexing table for such manufacture. Before this machine was put into operation, the outer races, and also the bearing seats in gears, had to be rough ground and finish ground in a time of approximately 6 minutes. Currently, only rough grinding is carried out with a slightly coarser wheel, followed by automatic honing. The honing time is only 20 seconds, producing a surface finish of 1 to 3 micro-inches. The honing operation is carried out by the short stroking method, and the table stroke is used only for bringing the part into honing position. The complete honing cycle is automatic, the only manual operations being loading and unloading of the parts.

Fig. 6. Automatic transfer conveyor on machine honing wheel brake cylinders. Honing time is 15 to 20 seconds

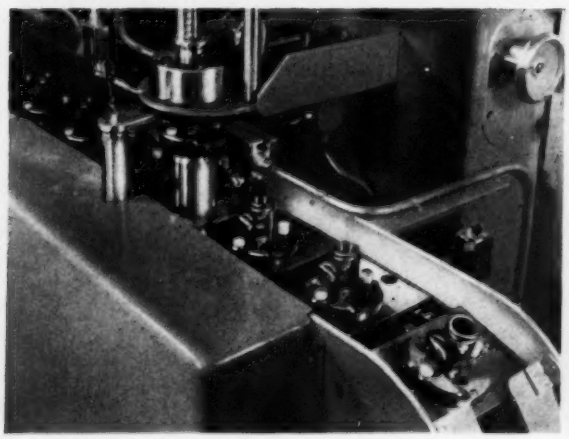


Fig. 7. Rotary indexing, loading-unloading table on machine honing bearing races. Honing time is 20 seconds

There is a
HOFFMANN
BEARING
For every class of Vehicle
and for every Antifriction
Bearing Position
HOFFMANN
BALL AND ROLLER
BEARINGS
THE HOFFMANN MANUFACTURING CO. LTD., CHELMSFORD, ESSEX

Get on top of those stresses and strains

by using Saunders-Roe Foil Strain Gauges.

For example one application recently carried out by our Foil Strain Gauge Consultancy Service was monitoring of strains in cylinder liners of ship's diesel engines undergoing sea trials.

Others include monitoring tensions in multi-rope goods and passenger Lift installations, the measurement of the effects of wind forces on radar aerials and the measurement of torque in ship's roll stabiliser installations.

Whatever your interests, Saunders-Roe Foil Strain Gauges can help you—and at a cost compatible with everyday use.

Strain Gauges can also be supplied already incorporated in transducers for monitoring parameters such as torque, horse-power, pressure, weight and tractive effort.

For details of Saunders-Roe Foil Strain Gauges and Consultancy Service, write to:

SAUNDERS — ROE

ELECTRONICS DIVISION

EAST COWES · ISLE OF WIGHT

CPH/SRE/19

Final Drives by the million !
Since E.N.V. pioneered spiral bevel, and later, hypoid drives, they have supplied literally millions of crown wheels and pinions, differentials and complete axles to British and European vehicle makers.
E.N.V. have production and heat treatment facilities for quantity production of final drives, axles, gearboxes and associated transmission components, and offer co-operation with vehicle designers from the project stage.

ENV FOR GEARS

E.N.V. ENGINEERING CO. LTD., HYTHE ROAD, WILLESDEN, LONDON, N.W.10. Tel.: LADbroke 3622

AP91

Q What exactly do you mean by QD ?

D It's a piston for re-vitalising tired engines.

Q Tired ?

D After twenty or thirty thousand miles, especially on heavy duty work, most engines tire a little. Tiring is expensive. Your accounts are showing that several of your vehicles are heavy on oil. Your drivers are complaining of low power and are taking longer over their journeys. Fundamentally, that's largely due to cylinder wear.

Q In other words, you think I need new pistons ?

D Probably. It depends upon the amount of wear involved. It is possible that the trouble can be cured with Duaflex alone.

Q Duaflex ?

D The D part of QD. When piston wear is not excessive you can fit Duaflex Rings to existing pistons to compensate for cylinder wear, restore power, cut oil consumption, and give thousands more miles of lively performance. All for about a sixth of the cost of a replacement engine.

Q And if the pistons are badly worn ?

D Then new QD pistons are the answer, complete with Duaflex and Quickseat Top Rings. Your service engineer can determine the best course after measuring the bores and pistons. You can rely on these products curing the trouble. Wellworthy have been specialising in this field almost since motoring first began. **Q.E.D.**

If you have got vehicles in your fleet running up your lube oil bills, heavy on fuel and doing far too much low gear work, fit QD. Write now for literature and address of nearest Stockist to Dept. A10

WELLWORTHY
THE CHOICE OF THE EXPERT

WELLWORTHY LTD LYMINGTON HANTS

THE HARSHAW CHEMICAL COMPANY, after years of research and development work, was the first to find that a sulphur-free nickel gives greater corrosion-resistance. This fact led to the development of the Harshaw Perflow nickel plating process.

Further research showed that use of the sulphur-free Perflow nickel deposit as a base coating, followed by a bright nickel deposit from a compatible bath, would give a Duplex deposit with a further improvement of corrosion-resistance.

Accelerated tests and outdoor exposures by leading car manufacturers and parts suppliers indicate that the Harshaw Perflow-Perglow Duplex nickel plate is comparable to and frequently better than buffed dull nickel and is unequalled by any bright nickel. This process provides the ideal nickel base for first quality chromium plate.

HARSHAW

Write for details of this process to

HARSHAW CHEMICALS LIMITED

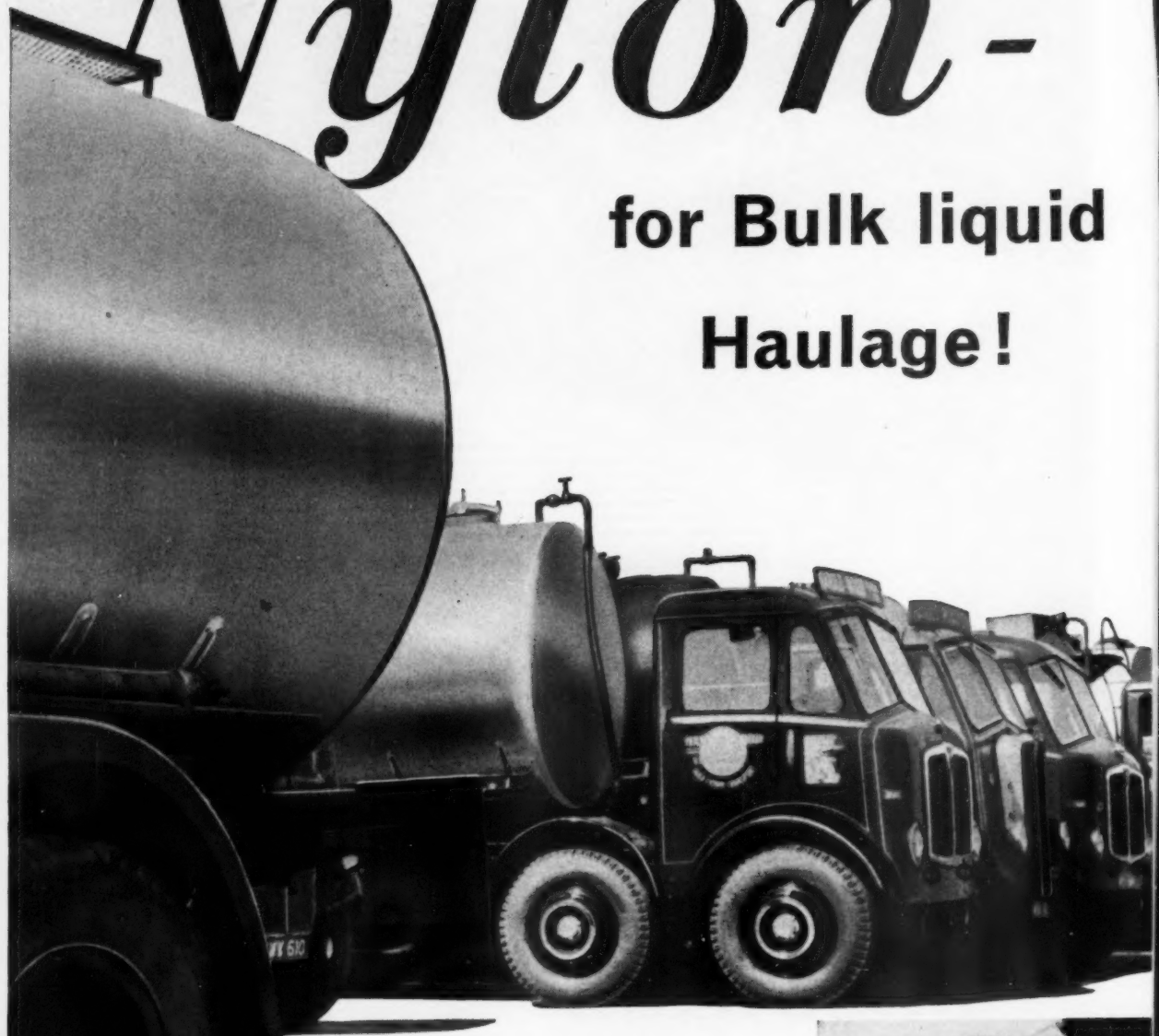
ELEANOR CROSS ROAD WALTHAM CROSS HERTS

Tel: Waltham Cross 24957 Grams: Harshaw Waltham Cross

TGA HP.CC

Nylon-

for Bulk liquid Haulage!



B Nylon S British Nylon Spinners Limited · 68 Knightsbridge · London · SW1

cuts the bill

Harold Wood & Sons Limited are amongst the biggest bulk liquid haulage contractors in Britain. A large proportion of their fleet of more than 300 road tankers is now running on nylon-corded tyres and their performance is excellent. Mileage figures to date are as good as those for any other type of tyre and nylon-corded tyres can be remoulded time and again. Many of the tyres in current use are running on their second remould. Some are on their third.

This firm regards remoulds as the most effective way of reducing tyre costs per mile—and no wonder. A remould costs half as much as a new tyre, and gives nearly the same mileage. Harold Wood & Sons find they are already getting three lives for the price of two tyres and are confident that even this can be improved.

The number of times nylon-corded tyres can be remoulded is only one of the advantages they have to offer commercial operators. Nylon is the toughest tyre cord material in use to-day. It is setting new standards of reliability and safety. Here are some of the ways in which nylon scores over the other tyre cords:—

It's *Nylon* for lasting strength

* Nylon can take it

Bumps, pot-holes, level crossings, high kerbs mean nothing to nylon. Nylon-corded tyres take the most terrific punishment without turning a hair.

* Nylon is unaffected by water

Nylon-corded tyres are unaffected by water seepage through casing cuts and give the same high performance wet or dry. Nylon maintains its strength well and never rots.

* Nylon is best for flex resistance

Nylon stands up superlatively well to the bending and twisting to which all tyres are subjected. Nylon's flex resistance is better than that of any other tyre cord.

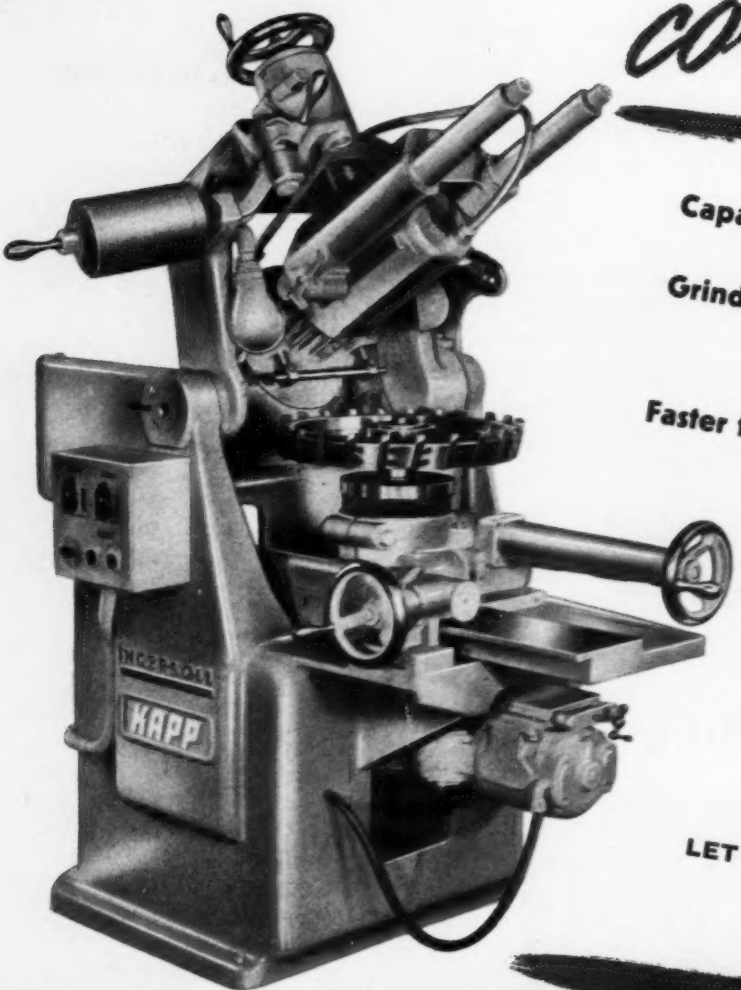
* Nylon is cooler running

Nylon cords generate less heat than any other tyre cord and run cooler on long journeys.

For a modest premium nylon-corded tyres can save you time, money and frustrating delays. For more information about them, please get in touch with your usual supplier. He will be happy to tell you *all* about them.

KAPP INGERSOLL CUTTER GRINDER

Slash cutter servicing costs!



Capacity 4" to 30" dia. cutters.

Grinds cutters complete in one setting.

Faster than standard grinders.

Accuracy is assured by single setting.

Simple and easy to operate.

PLEASE LET US DEMONSTRATE TO YOU.

VAUGHAN ASSOCIATES LIMITED

4 QUEEN STREET CURZON STREET LONDON W.1.
Tel: GROSVENOR 8362 5
MIDLAND OFFICE AND DEMONSTRATION ROOM
WILFORD CRESCENT NOTTINGHAM *Tel.* Notts 88008

NRP 1607

But-zis-is-ow-we-drive-in-my-country

There are lots of different kinds of driver on the road. A good many different kinds of fuel too. The safest thing to do is to stick to BP Diesel – available at Agency sites throughout Britain. With a Shell and BP Diesel Agency card your drivers can fill up with BP Diesel on credit, or cash at agency rates.

PETROL AGENCY DERV

THIS IS THE SIGN THEY SHOULD LOOK FOR

BP DIESEL

FOR *Diecastings as strong as steel*

ALUMINIUM BRONZE CO., LTD.

Wallows Lane · Walsall · Staffs.

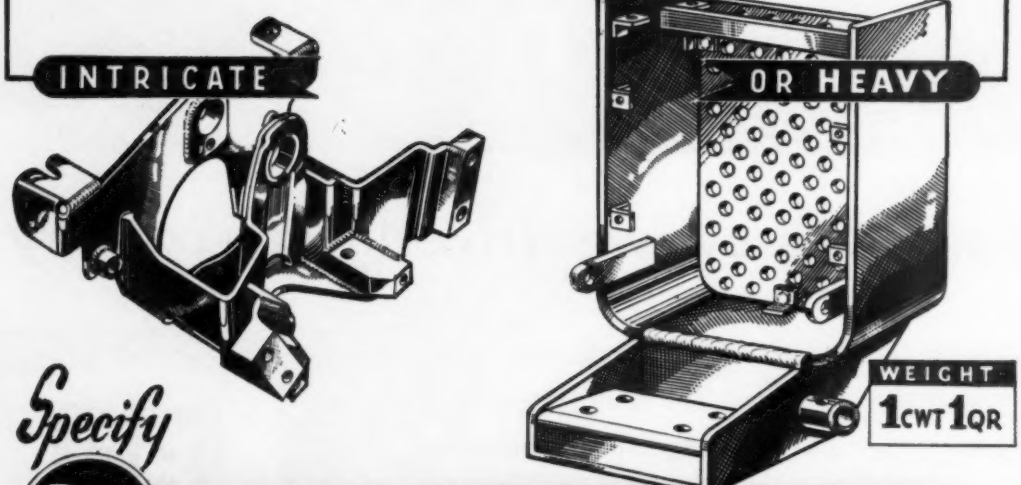
Telephone: WALSALL 2108 (3 lines)
Telegrams: "ABCO · WALSALL"

SIMPLE

INTRICATE

LIGHT

OR HEAVY



Specify

BP *The Quality* PRESSINGS

Manufactured by

B. PRIEST & SONS LTD · OLD HILL · STAFFS · ENG.

Telephones: CRADLEY HEATH 66501/4

Telegrams: "BOLTS OLD HILL, CRADLEY HEATH"

come to

LAPOINTE

for better

broaching

Vertical Internal
Broaching Machine
broaching Crown Wheels
(bore 7¼"/9" diameter)
fully automatic loading
and unloading.

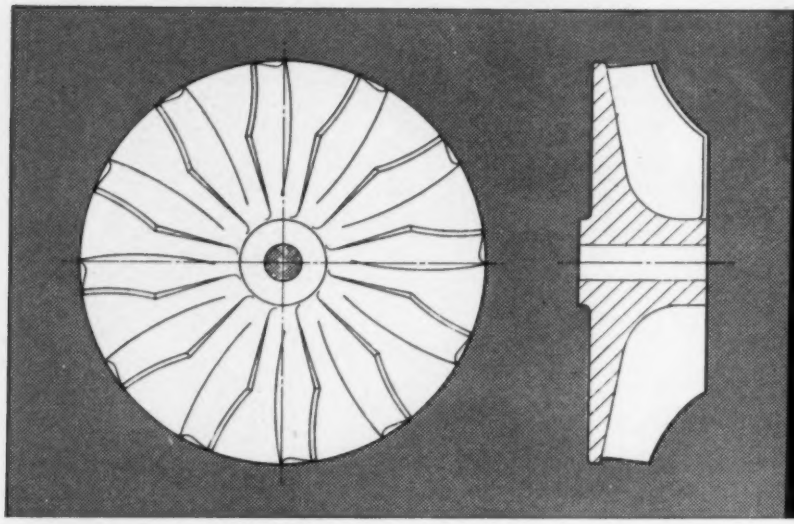
Capacity : 5/50 tons.
Broach lengths : 42/68 inches.
Can be supplied for
1, 2, 3 or 4 stations.

British Made

The Lapointe Machine Tool Co Ltd

Otterspool Watford-by-Pass Watford Herts
Telephone Watford 31711/2/3/4 Cables Lapointe Watford
Also The Lapointe Machine Tool Company Hudson Mass. USA

"STELLITE" cobalt base castings for high temperature use



Ease of casting produces intricate shapes to highest standards of soundness, accuracy and surface finish

Excellent high temperature properties

Unlimited supplies of alloy available

Competitive price

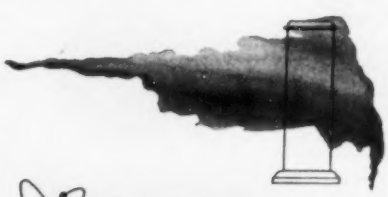
High scrap value of metal

DELORO STELLITE

DELORO STELLITE LIMITED · HIGHLANDS ROAD · SHIRLEY · SOLIHULL · WARWICKSHIRE
DELORO STELLITE DIV. OF DELORO SMELTING & REFINING CO. LTD. BELLEVILLE · ONTARIO · CANADA
A.D. NO. 290

The liquefaction of gases is an important branch of low temperature physics. Its importance is stressed by the fact that, of recent years, increasing use has been made in both industry and science of liquefied gases, such as oxygen, nitrogen, helium and hydrogen.

In the automobile industry new methods of increasing the flow of production are constantly being sought. One such method, involving the use of liquid oxygen, or nitrogen, is defined by the term "Shrinkage Fits". This denotes a process of freeze-shrinking the shaft or insert by immersion in either of these liquefied gases, down to minus 185/196°C. The simplicity of such a process, combined with its saving of many hours, gives it a considerable advantage over more traditional methods.



Here, at Dupree Swift, we make the spherical copper vacuum container (above right) for storage of liquid oxygen or nitrogen, and the cylindrical, or soaker type (left) for immersion of the insert, as stated above, in either of these liquefied gases.

Our catalogue will tell you more about us—just write or telephone.

DUPREE SWIFT & COMPANY LIMITED

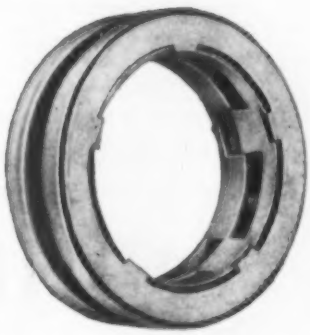
23/25, Broadwall, Blackfriars, London, S.E.1.

Established 1919 *Tel: WATerloo 5750*

"All the world's

<u>Our</u> stage"...

Manufacturers all over the world have discovered the importance of fitting SUPERFECT Oil Seals and Hydraulic Packings for perfect performance under the most exacting conditions.



There is a type of Seal to meet virtually every need. When a new project is in the course of development, our Research Department is available for the SUPERFECT solution to every sealing problem.

A Brand new catalogue is in the course of preparation. May we reserve one for you. Our technical representative will be pleased to call by appointment to discuss your particular problem.

SUPERFECT

SUPER OIL SEALS & GASKETS LTD.

KINGS NORTON FACTORY CENTRE, BIRMINGHAM, 30

'Doc'umentary evidence

'Doc', the personification of all our scientific brains, has at his disposal a library in which are filed nearly 20,000 references to previous experiments and their results in all fields of rubber technology.

If he cannot there trace a ready-made answer to your problem, he is additionally blessed with scientific and technical resources plus experience which will rapidly provide a bespoke result.

JOHN BULL *Rubber*

Solves your problems

JOHN BULL RUBBER CO. LTD. (INDUSTRIAL SALES DIVISION) LEICESTER • TELEPHONE 36531

METAL & ASBESTOS GASKETS *for VEHICLE manufacturers*

Manufacturers' Enquiries only

MANUFACTURERS OF JOINTS & GASKETS FOR ALL TYPES OF I.C. ENGINES & POWER UNITS

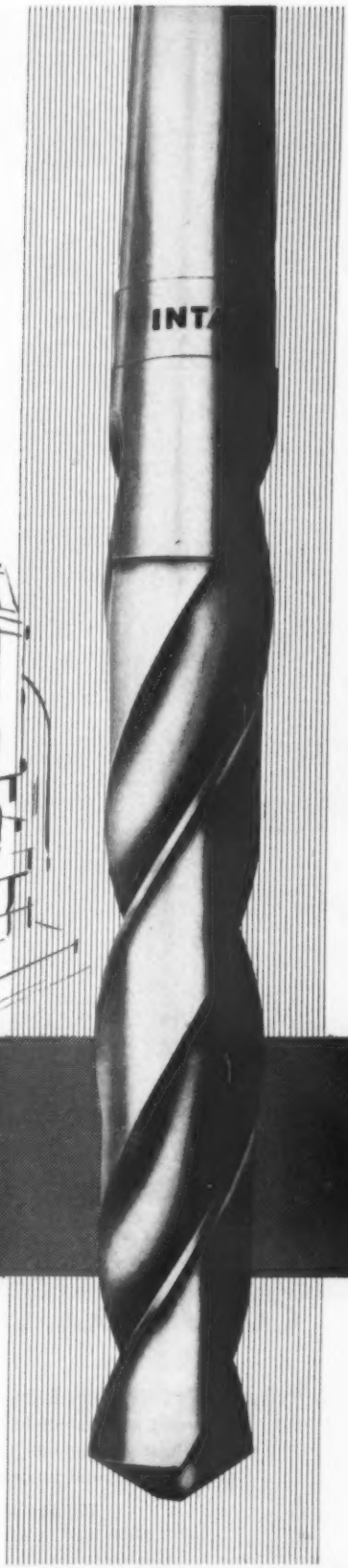
Specialists in the quantity production of small metal pressings.

THE COPPER & ASBESTOS WASHER CO. LTD.
LEIGHSWOOD INDUSTRIAL ESTATE, NORTHGATE, ALDRIDGE, STAFFS.
Telephone: ALDRIDGE 52951.

small drills
or

LARGE DRILLS

—— insist on



INTAL

The twist drill par excellence

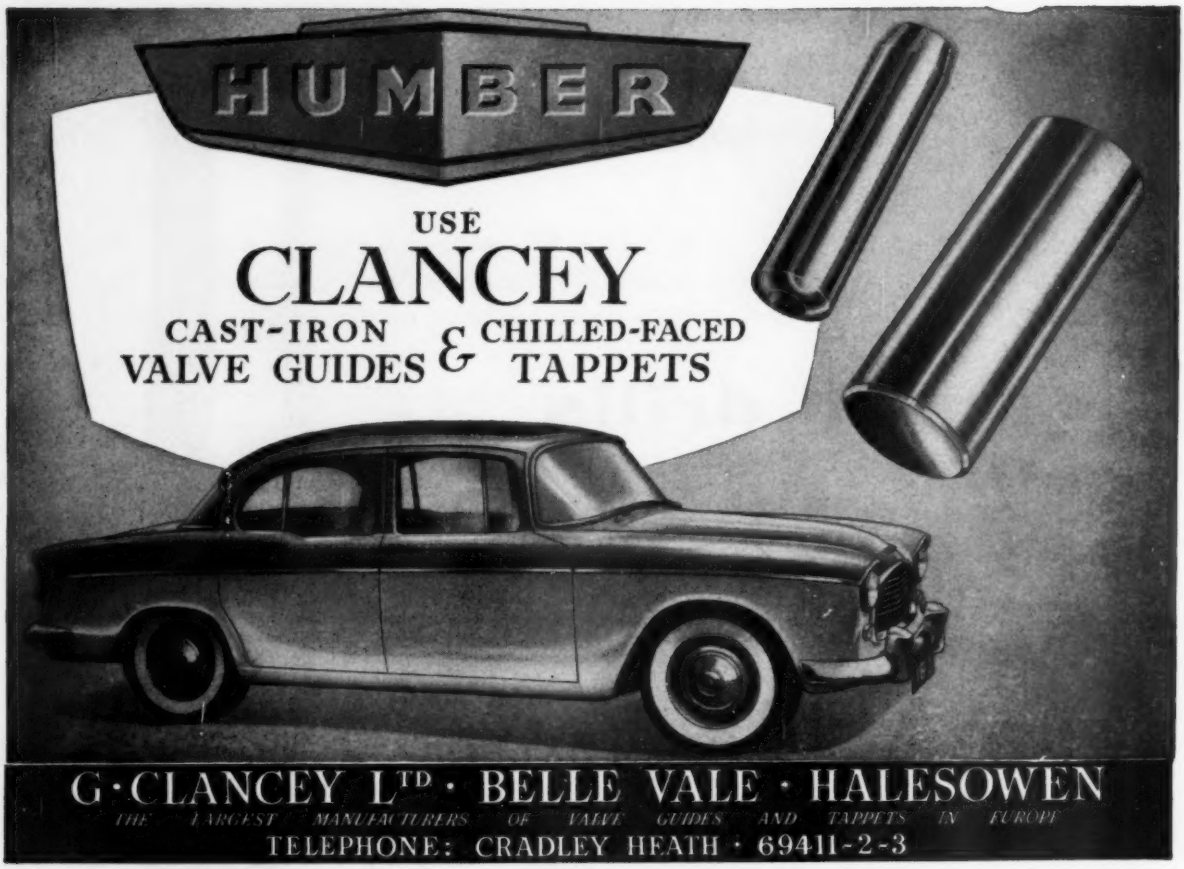
London Office and Stock
6/9 Red Lion Market, Whitecross Street, London, E.C.1. *Tel:* MONarch 8771-2

Birmingham Office and Stock
81 Headingley Road, Handsworth, Birmingham. *Tel:* NORthern 8211

Manchester Office and Stock
177 Dickenson Road, Manchester, 13. *Tel:* RUSholme 7313-4

Scottish Agent and Stockist
John Warden, 50 Wellington Street, Glasgow, C.2.
Tel: City 6994 (2 lines) *Grams:* Precise, Glasgow

THE INTERNATIONAL TWIST DRILL CO. LTD. INTAL WORKS, WATERY STREET, SHEFFIELD 3
Telephone : 23072 (3 lines) ***Grams : "Fluted, Sheffield"***


HUMBER
USE
CLANCEY
CAST-IRON & CHILLED-FACED
VALVE GUIDES & TAPPETS
G·CLANCEY LTD · BELLE VALE · HALESOWEN
THE LARGEST MANUFACTURERS OF VALVE GUIDES AND TAPPETS IN EUROPE
TELEPHONE: CRADLEY HEATH · 69411-2-3

DG

YOUR NEW DESIGN

Talk to **Delaney Gallay** about the Heater

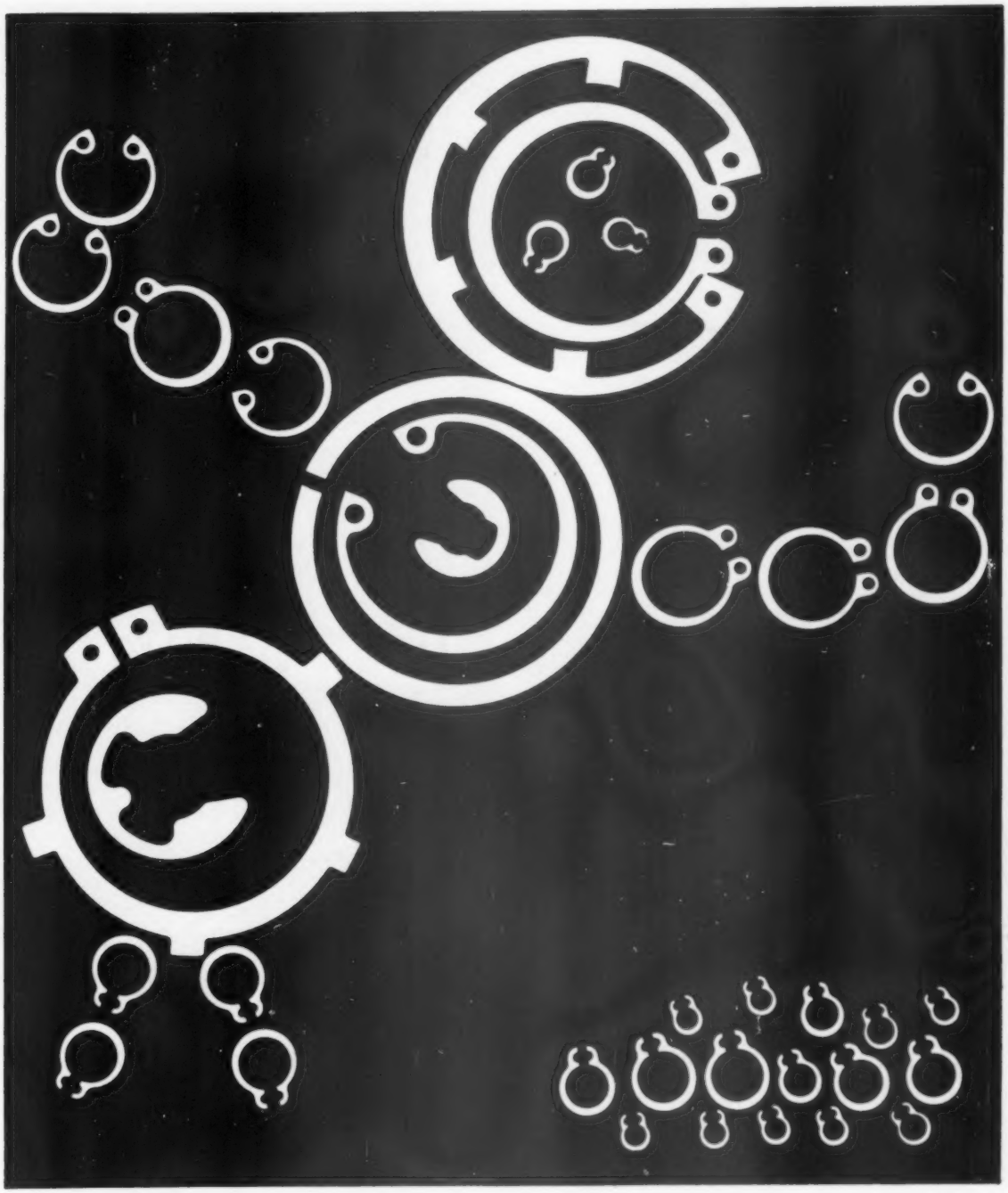
We have a very great deal of experience in the design and development of car heating, demisting and air conditioning equipment, together with extensive production capacity.

Whilst you are still in the design stage, why not have a chat with us? We will be glad to design and produce something to suit your requirements.

We are also specialists in radiators, tanks and presswork.

Vulcan Works, Edgware Rd, London, N.W.2.
Telephone: GLAdstone 2201.

Delaney Gallay LTD



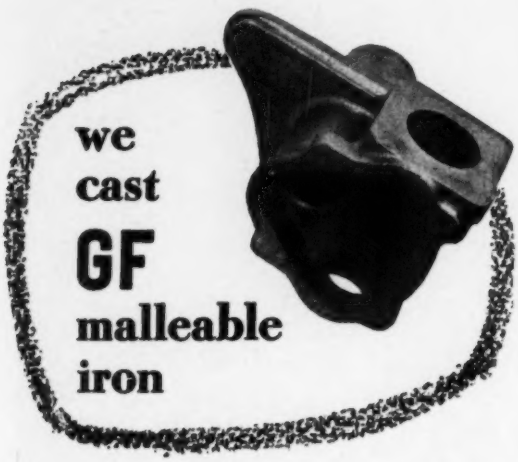
"SEEGER CIRCLIPS*... easy to fit and 360° safe!"

**Seeger Circlips are on the Rolls-Royce approved list*

Automotive Engineering Limited

One of the Sheepbridge Engineering Group
The Green, Twickenham, Middlesex
Telephone: Popesgrove 2206/9 Telegrams: Motif, Twickenham

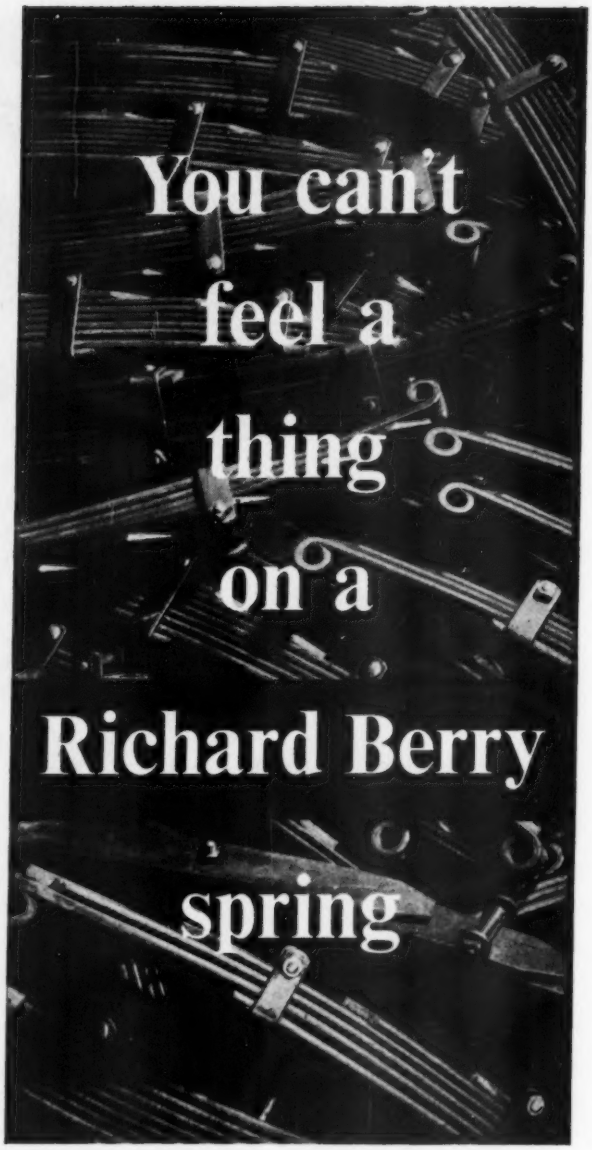
. . . on the virtues of other materials.
We merely say that **GF** Malleable Iron
is better. Better in many ways:
in reliability, for instance—
GF is always "up to sample".
In accuracy—**GF** casts perfectly.
In machinability—**GF** cuts cleanly
and takes a high finish.
In strength—its yield point is 18 to 22
tons p.s.i., and its ratio of yield to
ultimate strength as high as 60% to 65%.
Please ask us for more information.



The applications of
GF *Malleable Iron*
are virtually unlimited.
Please consult us when
you next require castings.

GF MALLEABLE CASTINGS

BRITANNIA IRON & STEEL WORKS LIMITED
A member of the George Fischer Group (Switzerland)
BEDFORD Telephone: Bedford 67261 **ENGLAND**
bis 9



With over 100 years experience behind them
Richard Berry answers the call for high speed
and comfort, with their new road spring factory.
These easy riding springs, made by skilled craftsmen
are made to endure the worst road conditions
in Britain and all parts of the world.

Write for a copy of "Leaf Spring Design" by Alan Hodgson.

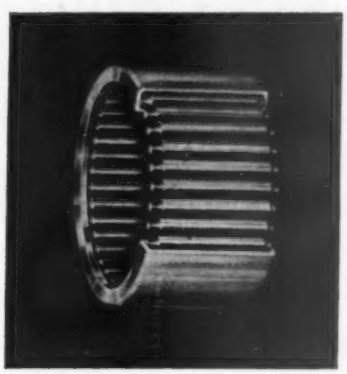
Richard Berry & Son.
Birmingham Rd., West Bromwich, Staffs.
Telephone: West Bromwich 1766/7/8.

ONE OF THE BROCKHOUSE COMPANIES

B59/E

with

TORRINGTON



The TRIUMPH **Herald** is justly described as "a new experience in motoring", having among other novel and attractive features independent suspension on all four wheels. TORRINGTON Needle Bearings feature in the drive-shafts and also in the already established gearbox application. Compactness and light weight combined with unequalled capacity and low starting and running friction at low cost make TORRINGTON Needle Bearings vital for efficient and economic design.

TORRINGTON BEARINGS

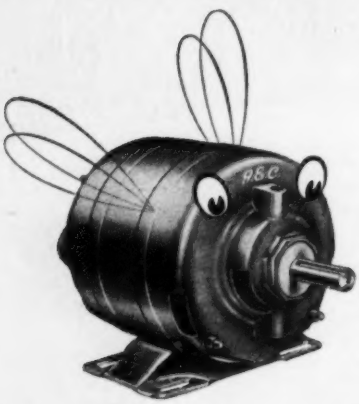
The Torrington Company Ltd. Bearings Division Torrington Avenue Coventry
London & Export Office: 7-10 Eldon Street, E.C.2.

Glasgow Office:
14 Moir Street, C.1.

G.E.C.

fractionals

put power where you want it



The Busy Bee from G.E.C.

Power for many purposes. Power to drive your own plant efficiently, or to add further distinction to the equipment you make and sell. Power. As much (up to 1 h.p.) or as little as you need, in a wide range of mountings, but always with the reliability for which all G.E.C. engineering is famous. Power, from sturdy, dependable G.E.C. Fractionals.
Most sizes and mountings are held in stock—that's another advantage of dealing with the G.E.C.

G.E.C. manufacture many types and sizes of fractional motors for light industrial and domestic drives—whether for your plant or products our engineers will always be pleased to help you choose the right motor for the job.

Fully detailed illustrated publication on application.

THE GENERAL ELECTRIC CO. LTD.,
MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

ENGINEERING AND TECHNICAL FACILITIES TO ENSURE QUALITY AND CONTROL AND TO PROVIDE SERVICE ON CASTING DESIGN AND TECHNICAL MATTERS

METALLURGICAL CONTROL
HIGH DUTY GREY IRON
HIGH STRENGTH & GOOD STRUCTURE
WEAR RESISTANCE
WITH FREE MACHINEABILITY

SAND CONTROL
DIMENSIONAL ACCURACY
SMOOTH FINISH

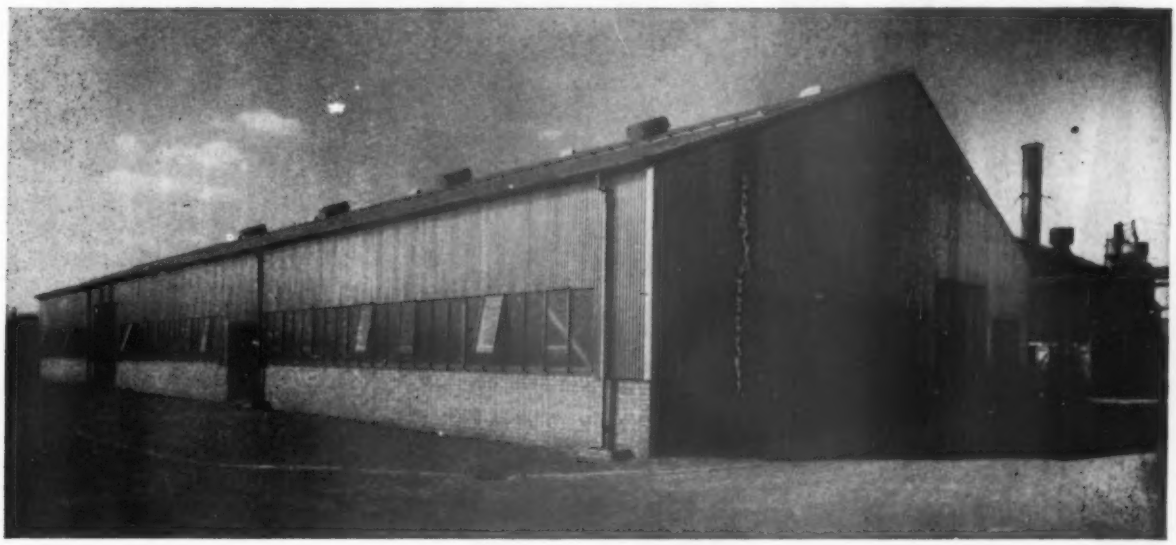
QUANTITY PRODUCTION CAPACITY

SERVICE

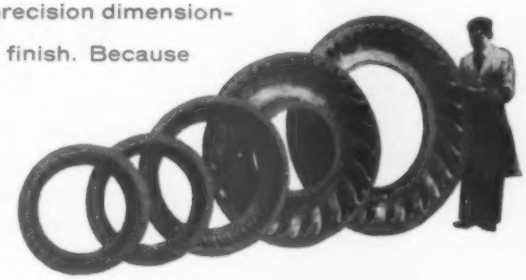
C&B SMITH
LIMITED
IRONFOUNDERS
WOLVERHAMPTON

CBS

Extending our Facilities



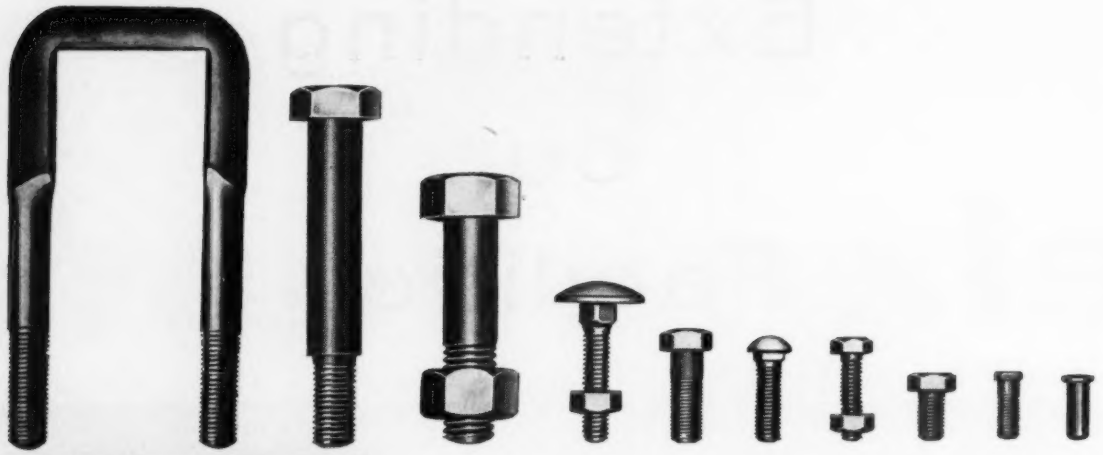
To deal with constantly increasing demands, this new extension to the William Mills Works at Wednesbury has been built specifically for the production of light alloy castings by plaster moulding. Castings produced by this method are of high precision dimensionally and have an excellent surface finish. Because of the quality and accuracy of the castings, tyre moulds of the types illustrated are produced by the plaster moulding system.



William Mills Limited

FOUNDERS IN ALUMINIUM ALLOYS

FRIAR PARK FOUNDRY, FRIAR PARK ROAD, WEDNESBURY, STAFFS. TELEPHONE: STONECROSS 2276/7
AP 150



WILEY

Whatever your fastening problem, Wiley can make a bolt for it—and a nut too—ask them!

make a bolt for it!

JAMES WILEY & SONS LIMITED, DARLASTON, STAFFS. *Telephone: James Bridge 2692.*

M-W.61

AT LAST

an interlock guard for hand presses

ARRESTAPRESS

Simple, efficient, easy to fit and inexpensive. What more can you ask of a press guard? That is why you should specify Udal Arrestapress guards for hand presses. But don't take our word for it. Buy one and try it out. We can deliver from stock and send you fitting instructions.

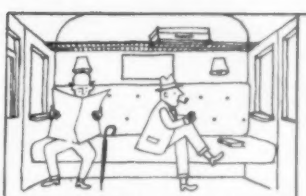
Udal Arrestapress guards are fully guaranteed and cost £8 12s. 6d. each for presses up to No. 5 size, and £9 15s. 0d. for size Nos. 6, 7 and 8.

UDAL

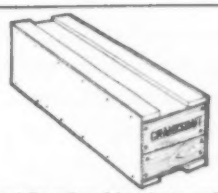
J. P. UDAL LTD., Interlock Works, Court Road, Birmingham, 12, Tel: CALthorpe 3114/6.

THE BOARD WE CAN TAILOR TO SUIT YOU EXACTLY

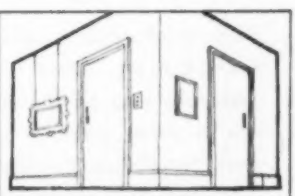
As well as being bent, blanked, and cut to almost any size, Bowater Board can be dressed up in all sorts of attractive colours and textures. For reasonably long runs, it can be given special hardening, softening, or other treatments to make it suitable for jobs like the ones shown here...



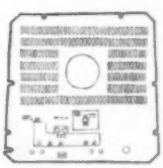
For British Railways carriage partitions, Bowater Board was specially treated for easier lamination of Melamine.



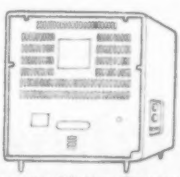
A specially softened board was produced for these crankshaft boxes, so that automatic nailing machines could be used.



By contrast, a specially stiffened Bowater Board was used for making these flush doors.



Another regular use—TV backs. Bowater Board is dark-stained so that overprinted circuit diagrams are clearly legible.



TV backs again: this time, Bowater Board was fine-meshed on the reverse side so it could take screening foil.

Another British Railways assignment: Bowater Board was specially adapted to make it easier to curve and shape railway coach ceilings.

Like a booklet and some samples to start you thinking? Write to:

Imagine how you can use

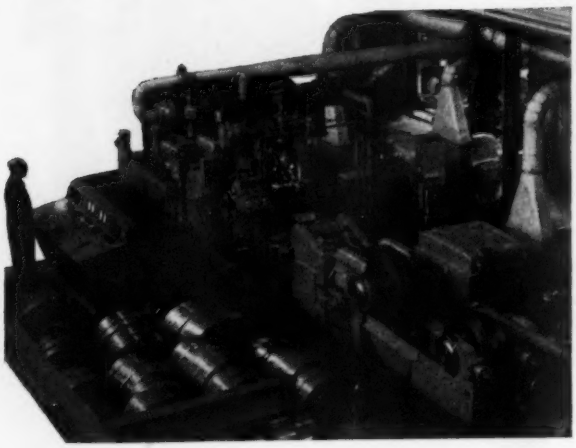
Bowater Board

BUILDING BOARDS DIVISION, BOWATERS SALES COMPANY LIMITED, BOWATER HOUSE, KNIGHTSBRIDGE, LONDON SW1. TEL: KNI 7070

CRC 6481

Now even closer tolerances on Habershon cold-rolled strip

New, fully-automatic electronically controlled plant in operation at Holmes Mills



Now you can depend even more on the traditional 'quality in quantity' of Habershon steel strip.

Faster production: micro-measurements more consistent than ever before: tolerances even closer than those required by the strictest specification—all this is made possible at Habershons by the recent installation of completely automatic plant.

Progress is our greatest product

Habershon

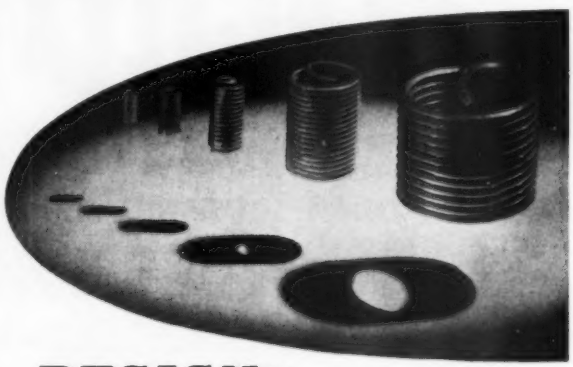
STEEL STRIP AND SHEET

J. J. HABERSHON & SONS LIMITED, ROTHERHAM
Telephone: 2081 (6 lines)
LONDON: Enterprise Works, Angel Road, Edmonton, N.18
Telephone: Edmonton 5081
BIRMINGHAM: Daimler House, Paradise Street, Birmingham, 1
Telephone: Midland 1966

There is nothing to equal the LEAD acid battery for reliability and economy

The technical officers of the Association are always glad to give individual assistance.

LEAD DEVELOPMENT ASSOCIATION, 18 Adam Street, London W.C.2
Telephone: WHitehall 4175. Telegrams: Leadevep, Rand, London



DESIGN or ACCIDENT . . .

. . . fit CROSS

THE BRITISH WIRE THREAD INSERT

Whether for incorporation in a new design or for renewing a stripped thread, Cross wire thread inserts are simple, accurate and effective. Normally made in high carbon steel, hardened and tempered, they are also available in stainless steel for ferrous applications (not recommended for use with light metals), and in bronze for non-magnetic service. Send for full particulars. B.S.F., metric, B.S.P., B.A., Whitworth, Unified, etc.

CROSS MANUFACTURING CO. (1938) LTD., BATH, SOM.
Phone: COMBE DOWN 2355/8 · Grams: 'CIRCLE' BATH.

NO DELAY

Holroyd HU	Single reduction underdriven with horizontal input and output shafts. Centre distances 3, 4, 5, 6, 7, 8, 9, 10 and 12 inches.
Holroyd HO	Single reduction overdriven with horizontal input and output shafts. Centre distances 3, 4, 5, 6, 7, 8, 9, 10 and 12 inches.
Holroyd HV	Single reduction with vertical output shafts and horizontal input. Centre distances 3, 4, 5, 6, 7, 8, 9, 10 and 12 inches.
Holroyd Verso	2½", 4", 6" and 8" centre distance. Suitable for underdriven, overdriven or side mounting.
Holroyd F	Made in three sizes—1⅛, 1⅞ and 2½ inch centre distance, and suitable for a variety of mounting positions.
All the above are available with any of the following ratios:— 5, 7½, 10, 15, 20, 25, 30, 40, 50, 60 and 70 to 1.	
All these can be delivered from stock.	

Did you know that our worm gear speed reducers can be delivered immediately from stock? These units go up to 12" centre distance and can be ordered in a choice of 340 combinations of the type, size, and ratio shown in the table here. If you want a speed reducer with a centre distance over 12", we can usually assemble and deliver it in a matter of days. Send for the 50-page book about Holroyd worm speed reducers and you will always have complete details of our whole range by you for quick reference.

Holroyd 90 YEARS OF GEARS

JOHN HOLROYD & CO. LTD., MILNROW, LANCASHIRE

CDC.197

the embodiment of this scientific age

Forward-looking engineers are embodying Heli-Coil Screw Thread Inserts in their designs because competition demands that they use only today's most advanced and successful techniques.

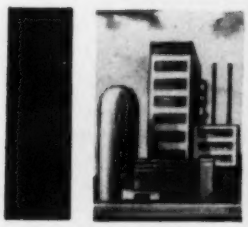
The Heli-Coil method of screw thread engineering can improve products in almost an infinity of ways. It can make dramatic cuts in time and labour costs.

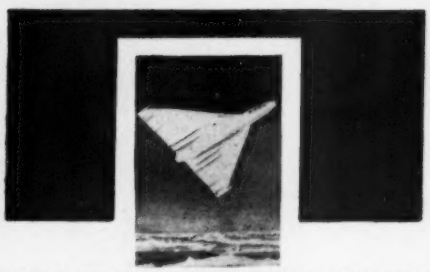
The Heli-Coil Insert is ideal for automation.

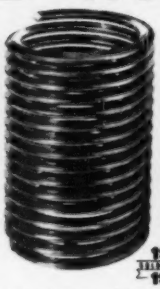
Why not have all the information in front of you — ask for — Sales Leaflet APL 48/E 2.

HELI-COIL*

SCREW THREAD INSERTS







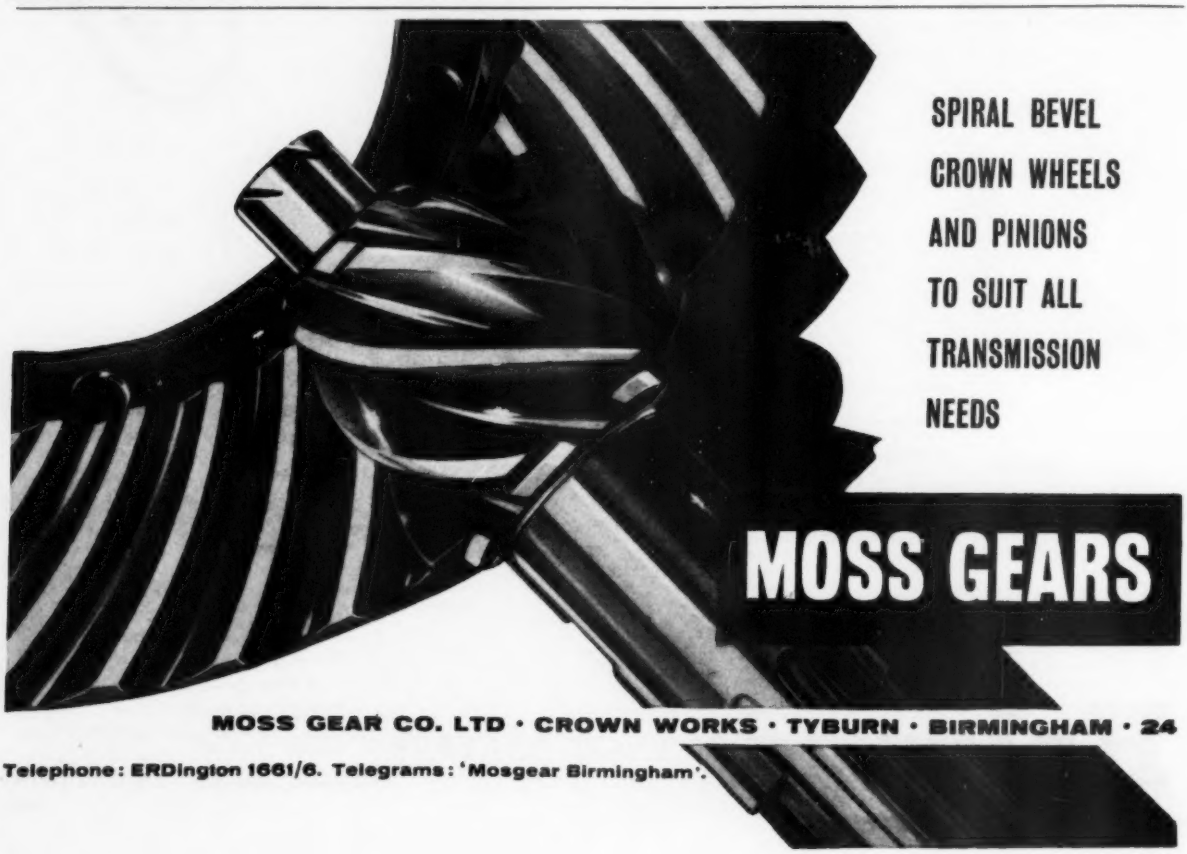
Your newest design . . . is it quite up to date?

1909 1959

*HELI-COIL is a registered trade mark

Write for more data on HELI-COIL inserts to **ARMSTRONG PATENTS CO. LTD. EASTGATE, BEVERLEY, YORKS.**

Tel: Beverley 82212 (6 lines)

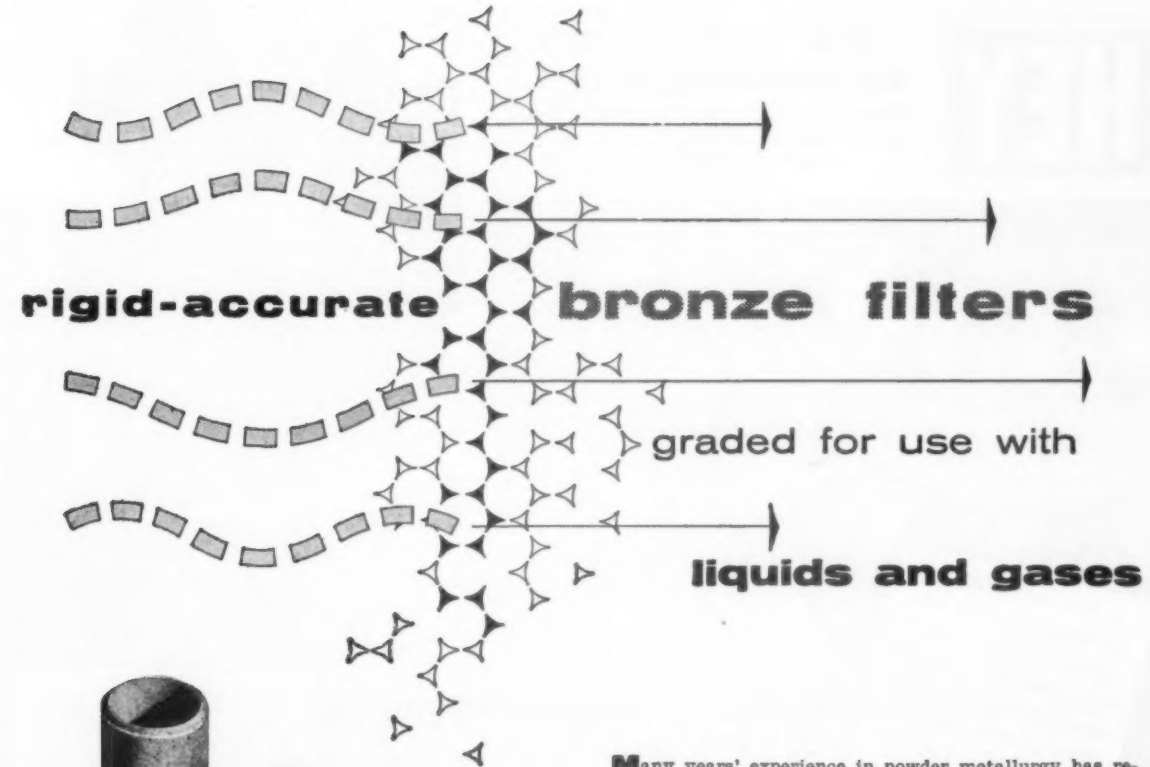


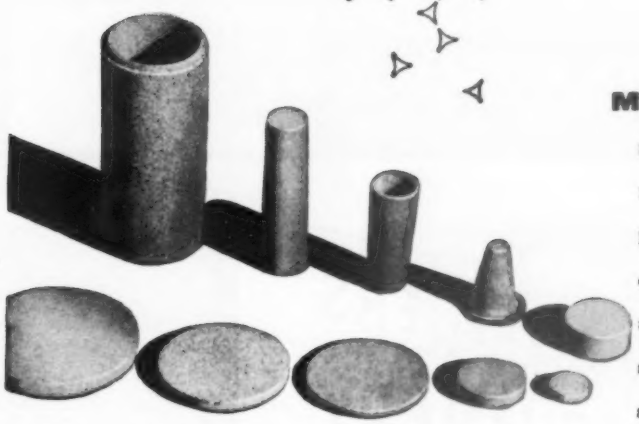
SPIRAL BEVEL CROWN WHEELS AND PINIONS TO SUIT ALL TRANSMISSION NEEDS

MOSS GEARS

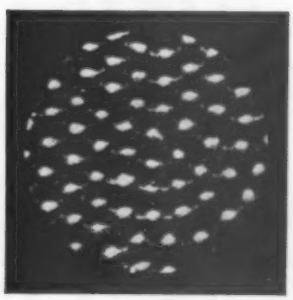
MOSS GEAR CO. LTD · CROWN WORKS · TYBURN · BIRMINGHAM · 24

Telephone: ERDington 1661/6. Telegrams: 'Mosgear Birmingham'.





Many years' experience in powder metallurgy has resulted in the development by BOUND BROOK of a porous material for the filtering of liquids and gases. It is produced from spherical metal powders of *closely controlled particle size* to give a rigid porous bronze structure of *uniform pore dimensions*. This metallic structure has excellent resistance to impact, is suitable for high pressure filtration in both directions of flow, and enjoys an almost indefinite life. The material is easily cleaned either by washing or by reversing the flow. Designed for such applications as Filter Elements, Flow Control Devices, Flame traps etc., Bound Brook bronze filters are available in six grades to suit required conditions, and in the form of discs, plates, cones, hollow cylinders etc. Special shapes can be made to suit customers' requirements. For further information send for leaflet "BOUND BROOK Bronze Filters".



This microphotograph shows a section of a Bound Brook Filter. Note the porous structure formed by the use of spherical metal powder.

A MEMBER OF THE BIRFIELD GROUP

Bound Brook Bearings Limited

Trent Valley Trading Estate, Lichfield, Staffordshire

Telephone: Lichfield 2027-8 · Telegrams: Boundless, Lichfield

HEY

GEAR TOOTH ROUNDING and CHAMFERING MACHINES

Automatic operation, High Production Rates on External and Internal Gears, Starter Rings, etc.

Used extensively by all leading gear specialists, automobile, aircraft, machine tool manufacturers, etc. Two models available for work up to 20in. and 10in. diameter. Illustrated data on request.

HEY ENGINEERING CO. LTD.
COVENTRY PHONE COVENTRY 88641

We also manufacture Rotary Cam and Profile Milling Machines, Short Thread Milling Machines, Multiple Drilling Heads and Machines, Tapping Machines, End Facing and Centring Machines, Special Machine Tools for High Production.

NRP1959

AUCTIONEERS & VALUERS OF PLANT, MACHINERY AND FACTORIES

SINCE 1807

FULLER HORSEY
SONS & CASSELL

10, LLOYD'S AVENUE · LONDON · E.C.3. Phone ROYAL 4861

Rathbone

Stainless Steel

by

Design

STAINLESS STEEL—the most useful modern metal—is being used more and more in the design of modern motor-cars. It is ideal for trim and accessories as it does not chip or peel. No special polishes are needed—all that is required to maintain the lustrous appearance of Stainless Steel is simple washing with hot soapy water.

FIRTH-VICKERS STAINLESS STEELS LTD., SHEFFIELD

is the only Company in Europe to devote its activities exclusively to the production and development of stainless and heat-resisting steels.

PUSH or PULL..

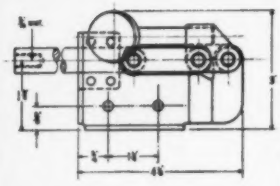
...it's all one - to the

Speetog PUSH PULL CLAMP

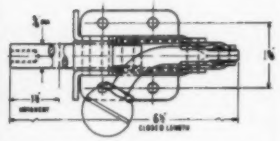
REGD. TRADE MARK

Patent Pending

This is the first Clamp designed to carry out both "push" clamping and "pull" clamping without adjustments or re-fitting to the clamp itself. No nuts, bolts or split pins to remove for this dual-purpose clamping.



Closed position for "push" clamping. Neat and compact.



Plan view of above. Reverse position for "pull" clamping.

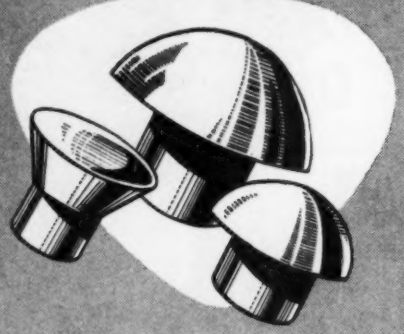
FULL LITERATURE SUPPLIED

Speed Tools Ltd

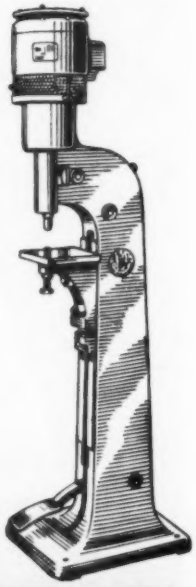
VEREKER HOUSE, GRESSE ST., LONDON W.1. Museum 1039/1099.

N.R.P.

IF YOU USE THESE



We make the widest range of rivet spinners on the market. They are universally used in the manufacture of every type of component for the Automobile Industry, especially, where a neat appearance is as important as a well-formed head. Send us a sample of the product you make and we will advise you on the best machine for the job.



YOU NEED THIS

TT RIVET SPINNING MACHINES

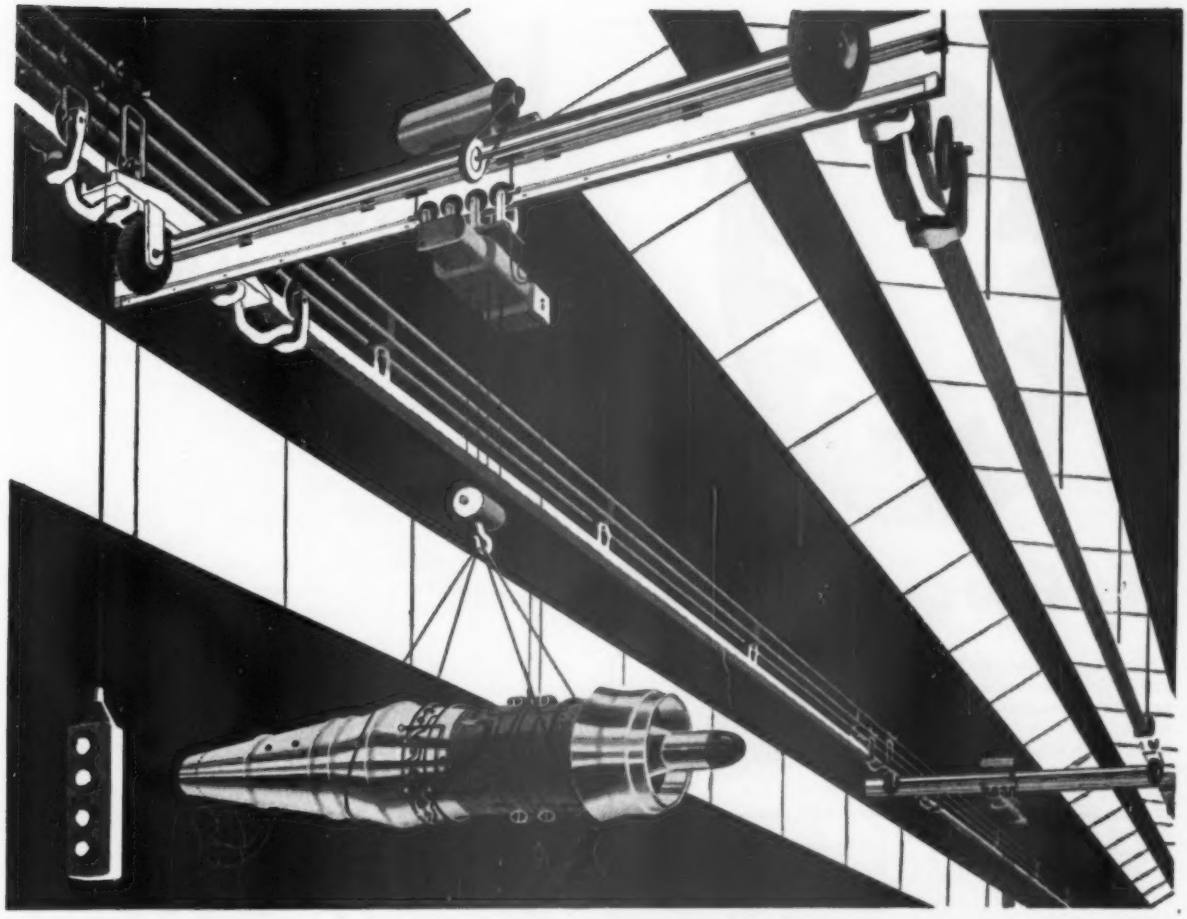
Illustrated: R.S5V.MD. ⅛ in. cap, foot operated model.

TURNER

MACHINE TOOLS LTD

63-68, PRINCIP ST., BIRMINGHAM, 4

Telephone: ASTON CROSS 2244



Industry's new motorways speed heavy loads OVERHEAD

After a survey of your plant, we produce a tailor-made plan. This and the estimate are free.

Loads up to ten tons can be transferred smoothly across the factory with Underslung Bridge cranes specially developed by British MonoRail. With spans up to 200 feet they will straddle wide bays. The underslung principle permits interlocking between parallel cranes, and the transfer of loads from one bridge to another. When the cranes are installed as part of a complete MonoRail system, the load can be transferred beyond the crane area to any part of the factory.

More advantages of MonoRail Underslung Cranes. Economical in headroom. Low in deadweight. All materials specially rolled, forged or cast for the job. Rubber-tyred crane drive eliminates track wear. Track of standard flange width and specifically designed for this purpose. Local, remote or automatic control optional.

A complete Overhead System. Underslung cranes are just part of the MonoRail handling and transfer system. It is an individually tailored system, covering every type of installation from the smallest gravity drive to the most complex automated systems.

IF YOU WANT TO GET A MOVE ON

Send for the man with the MONORAIL plan

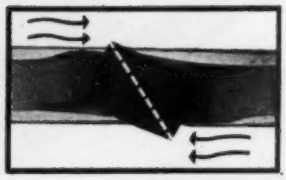
BRITISH MonoRail LIMITED WAKEFIELD ROAD · BRIGHOUSE · YORKS · TELEPHONE: BRIGHOUSE 2244

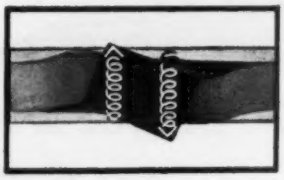
A Member of the Herbert Morris Group of Companies

TGA 8M

Why have twisted teeth?

The tapered teeth of "Shakeproof" lock washers are twisted to create exceptional spring tension between locking surfaces. Vibration makes this locking action more powerful. Each tooth acts as a strut to prevent the nut or screw backing off and the teeth's sharp edges anchor without milling. You won't find a tighter, more trustworthy lock than tapered-twisted tooth "Shakeproof" Lock Washers, available in hardened and tempered high carbon spring steel, or phosphor bronze.





A.I.D. APPROVED

"SHAKEPROOF"

REG. TRADE MARK No. B611535

LOCK WASHERS AND LOCKING TERMINALS

British Patents Nos. 406556 - 518146

BARBER & COLMAN LTD.
BROOKLANDS, SALE, CHESHIRE
TELEPHONE: SALE 2277 (3 LINES)
TELEGRAMS: "BARCOL" SALE

BARBER COLMAN

TRADE MARK

Dealers and Factors enquiries to the following appointed "SHAKEPROOF" Stockists:

George Boyd & Co. Ltd. 229 Buchanan Street, Glasgow C.1.
Brown Bros. Ltd. (all Branches)
Wm. Galloway & Co. Ltd. Blaydon-on-Tyne
F. Miller & Co. (London) Ltd. Rectory Road, Acton, London W.3.
Nettlefold & Moser Ltd. (all Branches)
Nobby Distributors Ltd. 438 Harrow Road, London W.9.
Wordrew Ltd. 173 Princess Street, Manchester, 1.

WORKED EXAMPLES IN MOTOR VEHICLE TECHNOLOGY

By R. W. BENT, M.I.Mech.E., etc. Here are 135 worked examples and nearly 200 unworked examples, most of them taken from the papers of various examining bodies. It forms an essential book for students preparing for C. and G., I.M.I., and similar bodies. Subjects include: Engine, Transmission, Suspension, Brakes and Steering, Force and Stress, Moments and Torque, Water and Power, Friction and Lubrication, Machines, Motion and Energy, Heat, Expansion, Magnetism and Electricity, Electrical Equipment, Fuels and Combustion. From all booksellers, 8/6 net.

PITMAN

Parker St., Kingsway, London, WC2

Good! a MITRE Drop Forging

We invite you to send for our sales folder which explains why MITRE precision Drop Forgings help to step up quality and production and reduce costs.

A. J. VAUGHAN & CO (MITRE WORKS) LTD

WOLVERHAMPTON ROAD WILLENHALL, Staffs. Phone 486/7

Tough as the rock

COR-TEN CAN TAKE IT

Super-tractor shovel shifting rocky overburden (Photograph by courtesy of Michigan (Great Britain) Limited)

WHEREVER you see steel taking savage punishment, the chances are it will be SCW Cor-Ten from The Steel Company of Wales.

With good reason. For over the past four years SCW Cor-Ten has built up a solid reputation for sheer toughness. More and more designers and users are specifying SCW Cor-Ten where high yield strength and corrosion and abrasion resistance are of major importance.

Cor-Ten is tougher

- Weight for weight, the yield strength is 50% higher than ordinary mild steel
  alternatively: Strength for strength, a saving of ⅓ of the weight is possible
- 4-6 times more resistant to atmospheric corrosion
- Highly resistant to abrasion and fatigue

Please write to us at the address below for further information or for technical assistance in the application of SCW Cor-Ten to your products

S·C·W BRAND Cor-Ten

RAILWAY ROLLING STOCK
AGRICULTURAL AND EARTH-MOVING EQUIPMENT
MINE CARS · POWER STATION INSTALLATIONS
BARGES AND SMALL CRAFT

THE STEEL COMPANY OF WALES LIMITED

ABBEY WORKS, PORT TALBOT, GLAMORGAN TELEPHONE: PORT TALBOT 3161

EKCO plastics *and the new ROVER 3-litre*

EKCO PLASTICS WERE RESPONSIBLE for the tooling and moulding of the instrument panel and steering column shroud for the new *Rover 3-litre.*

A complete assembly comprises up to nine separate mouldings, the structural parts being phenolic while the gear-change indicator plate and the instrument unit facing are in 'Diakon'. The lettering is moulded in the 'Diakon' panels, then filled in white and the panels sprayed black, the gear-change indicator being illuminated, in the finished assembly, to provide softly glowing markings for night driving. An interesting feature of the instrument panel facing is a unique Ekco technical development which entirely eliminates flow marks and knit lines around the five smaller holes. The complete project involves *eighteen* different mouldings, selective assembly allowing for the different requirements of alternative gearchange facilities and left- and right-hand drive.

✳ **If you have any moulding problem, however complex, EKCO PLASTICS have the designers and engineers to help you solve it.**

EKCO PLASTICS FOR INDUSTRY

EKCO PLASTICS LTD • SOUTHEND-ON-SEA • ESSEX *Members of the British Plastics Federation*

W.P.8.481.

See our Stand No. 496, Transport Service Equipment Section, International Motor Exhibition, 1959

A Really Fast "Torquer"

SAFEST & GREATEST TORQUE WRENCH OF THEM ALL.

Fast, Accurate, Foolproof. Will tighten 1, 100 or 100,000 nuts to exactly the same degree of tightness.

RANGE–8 Models cover 2 to 700 LBS/FEET. or .276 to 96.74 Kg./M.
⅜", ½", ¾" & 1" Square drive

Give generously on Poppy Day

Triple Safety Signal by TOUCH, SIGHT & SOUND
All models adjustable. No special setting rig required

TOOL UP WITH BRITOOL

CHROME ALLOY STEEL BRITOOL SERVICE TOOLS

Manufactured at
BRITOOL WORKS, BUSHBURY, WOLVERHAMPTON, ENGLAND.

SALISBURY GEARS-

HYPOID AND SPIRAL BEVEL GEARS UP TO 24" dia.

High quality gears produced on the latest machines up to 24" dia. for all vehicles and locomotives.

Axle shafts of all types. Special induction hardening process cuts cost, saves weight, and permits higher loadings.

SALISBURY gears are smooth, silent and longer-lasting because of their exceptionally good finish—the result of the most recent manufacturing techniques and of constant attention to detail.

THERE ARE other benefits of this careful quantity-production on the most modern machines . . . excellent quality in every way . . . less servicing . . . a really competitive price . . . and, most important, *delivery on time!* That's why Salisbury gears are increasingly specified by designers and manufacturers . . . for cars such as Jaguar and Aston Martin, for the new diesel locomotives, for the tough work of building and agricultural machinery.

Revacycle and Coniflex low-cost gears, for car and light commercial differentials up to 4½" pitch cone distance.

SALISBURY TRANSMISSION LTD

shares in the joint technical, research and productive resources of more than 20 famous firms, such as Laycock Engineering Ltd., Forgings and Presswork Ltd., Hardy Spicer Ltd., The Phosphor Bronze Co. Ltd., and others, who constitute the Birfield Group of Companies.

SALISBURY make most kinds of gears, axle shafts and transmissions for industry and commerce. And Salisbury technicians are always glad to co-operate on new projects and problems. Perhaps they can help you too? Please write for further details.

SALISBURY TRANSMISSION LTD

BIRCH ROAD · WITTON · BIRMINGHAM 6

Member of the Birfield Group

TRIPLEX

For High Duty Grey Iron

CASTINGS

SOLE MANUFACTURERS OF

CROMLEX

ALLOY IRONS

A MEMBER OF THE TRIPLEX FOUNDRIES GROUP

We make CASTINGS in Both Large & Small quantities for **ALL TRADES**

TRIPLEX FOUNDRY LIMITED

UPPER CHURCH LANE
TIPTON · STAFFS.
Phone: TIPTON 1293

Special Purpose Machines

FAIRMAN PRECISION TOOLS AND PRODUCTS LIMITED

PRESS TOOLS
PROTOTYPES
MOULDS
GAUGES
JIGS, ETC.

*'Phone: 3678

STATION RD (EAST), HORLEY, SURREY

A.I.D., M.O.S. AND ADMIRALTY APPROVED

The Modern Diesel

A standard work – brought right up to date

by Donald H. Smith, M.I.Mech.E.

new 13th Edition now available

Over 96,000 copies sold

Provides detailed information on the characteristics of high-speed diesel engines and their fuel injection equipment. The latest trends in fuel injection practice, combustion chamber design and fuel and lubricant developments are covered, engines for road, rail, marine and industrial uses are discussed and principal British, American and Continental engines in current use are reviewed.

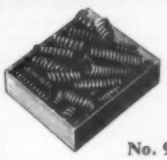
17s. 6d. net by post 18s. 8d. 288pp. Illustrated.

from leading booksellers.

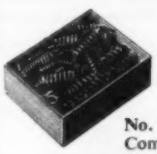
Published by Iliffe & Sons Ltd.
DORSET HOUSE, STAMFORD ST., LONDON, S.E.1

"If only I had an 18G ¾" expansion spring!"

No. 760. 3 doz. Assorted Light Compression Springs. 1" to 4" long, 22 to 18 S.W.G., ¼" to ½" diam. 6/6 each.



No. 98A. 3 doz. Assorted 1" to 4" long, ½" to ⅞" diam., 19G to 15G. 5/6 each.



No. 757. Extra Light Compression, 1 gross Assorted, ¼" to ⅞" diam., ½" to 2½" long, 27 to 19 S.W.G. 15/- each.

No. 388. ½ gross Assorted Small Expansion Springs. ¾" to 1½", 18G to 21G. 9/6 each.

No. 758. Fine Expansion Springs. 1 gross Assorted ½" to ⅞" diam., ½" to 2" long, 27 to 20 S.W.G. 15/- each.

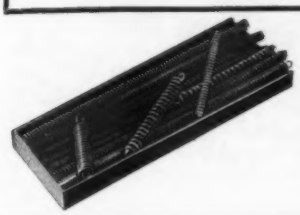
No. 466. ½ gross Assorted Small Expansion Springs ⅜" to 1½" long, 3/32" to 3/16" diam., 21G to 24G. 6/6 each.

There he is—stuck for a vital spring, the job hung up, all because he can't put his hand on the very thing needed to finish it. Don't be caught out like this—make practical use of TERRY'S BOXES OF ASSORTED SPRINGS where you'll find the exact spring you need for a thousand and one propositions. These handy boxes hold a wonderful variety of springs of every kind—compression, expansion, heavy, light, long, short, in the gauge you want —just when you want it.

Why not let us send you our fully illustrated list of BOXES post free?

HERBERT TERRY & SONS LTD
Redditch, Worcs.

(*Makers of Quality Springs, Wireforms and Presswork for over 100 years*)



No. 1024. 20 Compression Springs 12" long. ½" to ⅞" diam., 24G to 18G, suitable for cutting into shorter lengths; and 30 Expansion 1½" to 12" long, 5/32" to ⅝" diam., 22G to 16G. 24/- each.

TERRY'S ASSORTED SPRINGS

Cut production costs with Terry Wire CIRCLIPS (*Square Section*)
We can supply from stock in sizes from ½" to ⅝".

Have you a Presswork problem? If so let us have it and we'll help to solve it for you.

★Interested in Springs? Ninth Edition of "Spring Design & Calculations"—post free 12/6

H.T.27

The Motor Vehicle

By K. Newton, M.C., B.Sc., A.C.G.I., A.M.Inst.C.E., M.I.Mech.E. and W. Steeds, O.B.E., B.Sc., A.C.G.I., M.I.Mech.E.

The standard reference book for students, draughtsmen and owner-drivers

This book deals comprehensively with engines, carburation, carburettors, transmission, axles, brakes, steering, suspension and chassis details, and includes sections on modern petrols, fuel and lubricating oils. Both petrol and diesel engines are discussed in great detail and the present state of the gas turbine as applied to road vehicles is considered. The text uses non-technical language as far as possible, the aim being to provide an accurate but straightforward explanation of automobile engineering theory.
45s. net, by post 46s. 9d. 6th Edition.

Automobile Electrical Equipment

By A. P. Young, O.B.E., M.I.E.E., M.I.Mech.E., F.I.W.M. and L. Griffiths, M.I.Mech.E., A.M.I.E.E.

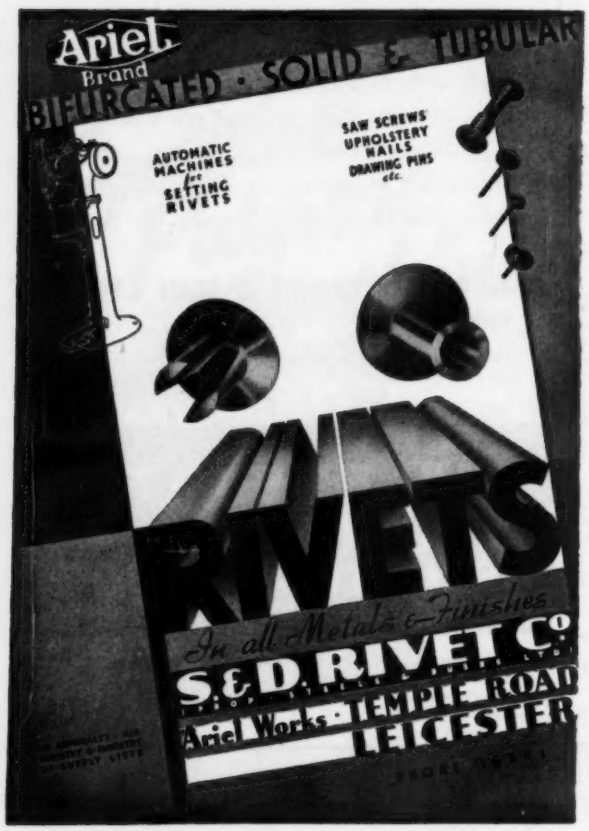
Theory and practice for students, designers, automobile electricians and motorists

Deals exhaustively with every aspect of generation, lighting, starting and ignition as applied to automobile engines and is invaluable to students, designers, repair men and owner-drivers. The fundamental principles underlying the design of each piece of equipment are fully explained, followed by the practical details, with diagrams and photographs to make every point clear.
30s. net, by post 31s. 6d. 6th Edition.

from leading booksellers

Published for "Automobile Engineer" by

ILIFFE & SONS LTD. DORSET HOUSE STAMFORD STREET LONDON S.E.1



Specialists in

MOULDED RUBBER HOSE

WE ALSO MAKE 3ft. STRAIGHT LENGTHS FROM ½" TO 3" BORE

With CANVAS INSERTION THROUGHOUT

CATALOGUE & PRICES ON APPLICATION

HERMETIC RUBBER CO. LTD.

HERMETIC WORKS · RYLAND ST · BIRMINGHAM 16
PHONE · EDGBASTON 0983/4 *Established 1895* GRAMS · HERMETIC, BIRMINGHAM

Photograph by courtesy of Marley Tile Co. Ltd.

TURNERS

DURAMAT[REGD]

CHEMICALLY BOUND GLASS MAT

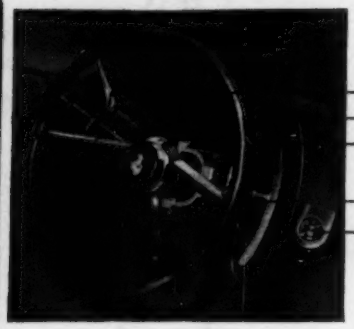
For information on all products in the Duraglas range, including glass yarn, roving, cloth, woven roving, tape and mechanically bound Duramat write for publication D3.

TURNER BROTHERS ASBESTOS CO. LTD. · ROCHDALE · ENGLAND

A MEMBER OF THE TURNER & NEWALL ORGANISATION

TA 152

F&J **HAND CONTROL FOR DISABLED DRIVERS**



C Clutch (on Gear Lever)
B Brake
A Accelerator
D Pre-set
E Vacuum Gauge

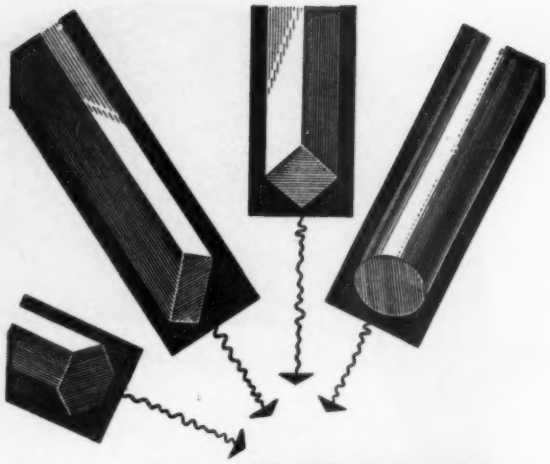
* Try out the controls for yourself on the new Triumph Herald on our Stand No. 386, International Motor Show, Earls Court.

Cars and commercial vehicles converted by our specialist fitting agents.
MOTOR SERVICES, Royal Works, Edge Lane, Stretford, Nr. Manchester.
ARNOTTS GARAGES LTD., Grange Road, Willesden Green, N.W.10.
REEVE & STEDEFORD LTD., Broad Street, Birmingham, 1.
LINCOLN CARS LTD., Great West Road, Brentford, Middx.
VICTORIA MOTOR CO. (BRISTOL) LTD., Temple Gate, Bristol, 1.
R. E. HAMILTON & CO. LTD., 32 Linenhall Street, Belfast.
GLANFIELD LAWRENCE (CARDIFF) LTD., 2-10 City Road, Cardiff.
WOOD'S AGENCIES, 375-377 St. Vincent Street, Glasgow, C.3.
List of Overseas Agents on request.

Designed and manufactured by

FEENY & JOHNSON LTD.

WEMBLEY *Telephone:* Wembley 4801/4802.



quality in special purpose steel

Dunelt

ALLOY AND SPECIAL CARBON STEELS

Black rolled, bright drawn or smooth ground, in heat-treated or unheated conditions. Free cutting steels, heat-resisting steels, die steels, shear blade steels, high-speed tool steels, stainless steels, valve steels, hollow steel bars.

DUNFORD & ELLIOTT (SHEFFIELD) LTD.
Attercliffe Wharf Works, Sheffield 9.
Telephone: 41121 (5 lines). *Telegrams:* "Blooms, Sheffield, 9".
London Office: Linford Street, S.W.8.
Birmingham Office: 25 Burlington Chambers, 118, New St.. 2

A useful Book for Garage Proprietors and Managers

AUTOMOBILE EFFICIENCY

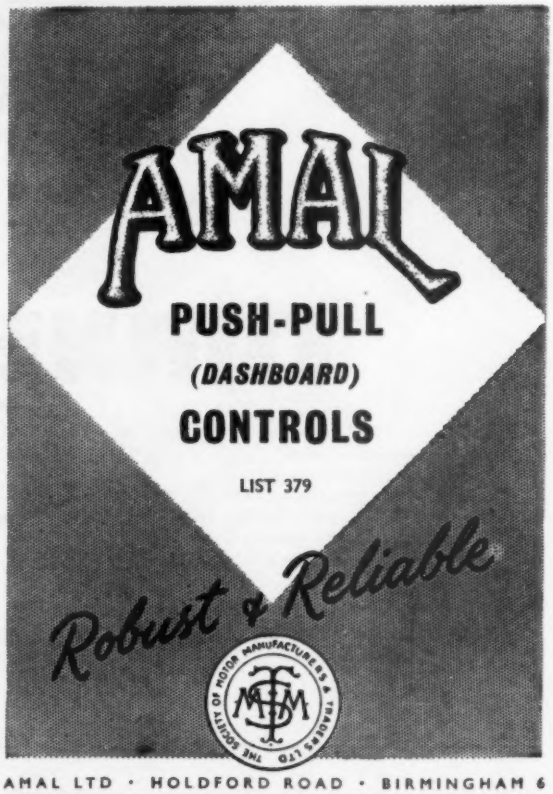
By E. T. Lawson Helme, A.M.A.E.T., A.M.I.M.I.

The author of this book claims that a possible outlet for new business lies in developing an organised service of engine tuning and testing. This service may comprise a reception department, a self-contained engine tuning and maintenance department, and a test service for checking the entire installation of any vehicle. The book gives practical advice on the organisation of such a service and explains how to bring it before the public by means of publicity and advertising schemes.

10s. 6d. net. *By post 11s. 3d.*

Obtainable at all booksellers. Published by:

TRADER PUBLISHING CO., LTD.,
DORSET HOUSE, STAMFORD ST., LONDON, S.E.1

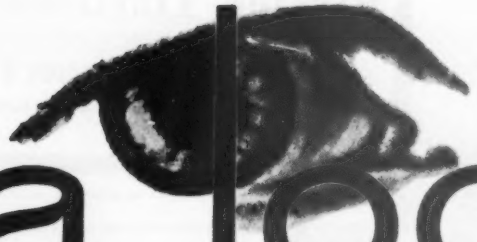


AMAL LTD · HOLDFORD ROAD · BIRMINGHAM 6
A.208

IF YOU WANT TO SEE AN

OUTSTANDING

ACHIEVEMENT
IN AUTOMOBILE ENGINEERING
HAVE



a look at
stand
No. 224

Simms

Simms Motor Units Limited
East Finchley · London · N.2.

Bushes and Bearings

ESCO T.C.C.

NEW CONTINUOUS CAST

Phosphor Bronze Rods

from ¼" solid to 4" solid or cored

Also Centrifugal Cast and Chill Cast
Range of sizes from ¼" solid to 11½" cored

★ *100% fault free* ★ *Super finish and quality*
★ *Any length up to 6 ft.* ★ *Dimensional accuracy*

Send today for full details

THE **EYRE** SMELTING CO. LTD.
Also makers of TANDEM WHITE METALS & ESCO GUN METAL INGOTS, etc.
TANDEM WORKS MERTON ABBEY LONDON SW19 Tel: Mitcham 2031
ALUMINIUM WORKS WILLOW LANE MITCHAM SURREY Tel: Mitcham 2248

IF YOU WANT THE FINEST RADIATORS

Then go to the specialists — Marston Excelsior. Radiators, in light alloys and in copper, are just some of the many different components that Marston design and fabricate. The highest standards of design, based on years of specialist experience, are represented in all these Marston's products, which are renowned for their utmost efficiency and outstanding reliability. Marston radiators are in front of the finest.

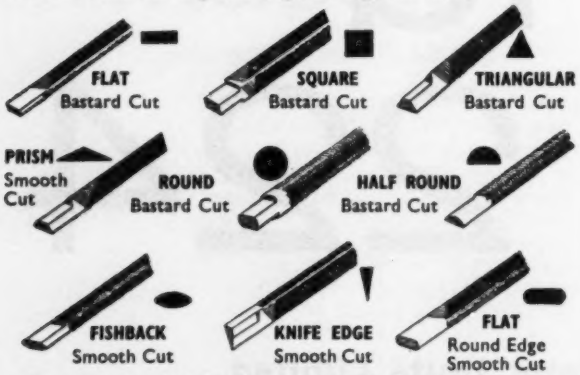
MARSTON EXCELSIOR LTD
(A subsidiary company of Imperial Chemical Industries Ltd.)
ICI
WOLVERHAMPTON & LEEDS
Tel: Fordhouses 3361 or Leeds 637351
MAR.238

HIGH GRADE MACHINE FILES

AVAILABLE EX-STOCK

Swiss Type Machine Files
61 Sizes, 4, 5 and 6 inches long for THIEL III and other Filing Machines
..Also 8 inches long for larger Filing Machines

THIEL



Diamond Impregnated Files for hardened steel and tungsten-carbide are also available.

WRITE TODAY for details of complete range.

WELSH HARP, EDGWARE RD, LONDON, NW2
TEL: GLADSTONE 0033

ROCKWELL MACHINE TOOL CO. LTD.

Also at BIRMINGHAM · Tel: SPRINGFIELD 1134/5 · STOCKPORT · Tel: STOCKPORT 5241
GLASGOW · Tel: MERRYLEE 2822

T/F

LONDON BRAND LONDON BRAND LONDON BRAND LONDON BRAND

The Designer asks:

Why leadcoated sheets?

- Superior anti-corrosion factor. The hot-dipped process applies the heaviest coating for the most durable protection. The steel base used is of the finest quality procurable.
- Ease in fabrication. No material is more readily worked. Soldering, in particular, can be easily carried out.
- Availability of sizes. A wide range, including 72" × 36" and 96" × 48" in any quantity. Special sizes up to 56" wide can be supplied.
- Write today for our useful Ivorine Pocket Data Card of sizes, gauges and sheet weights.

LONDON BRAND LONDON BRAND LONDON BRAND LONDON BRAND

LONDON BRAND LONDON BRAND LONDON BRAND LONDON BRAND

LONDON BRAND **'LONDON' BRAND** LONDON BRAND

TINNED & LEADCOATED STEEL SHEETS

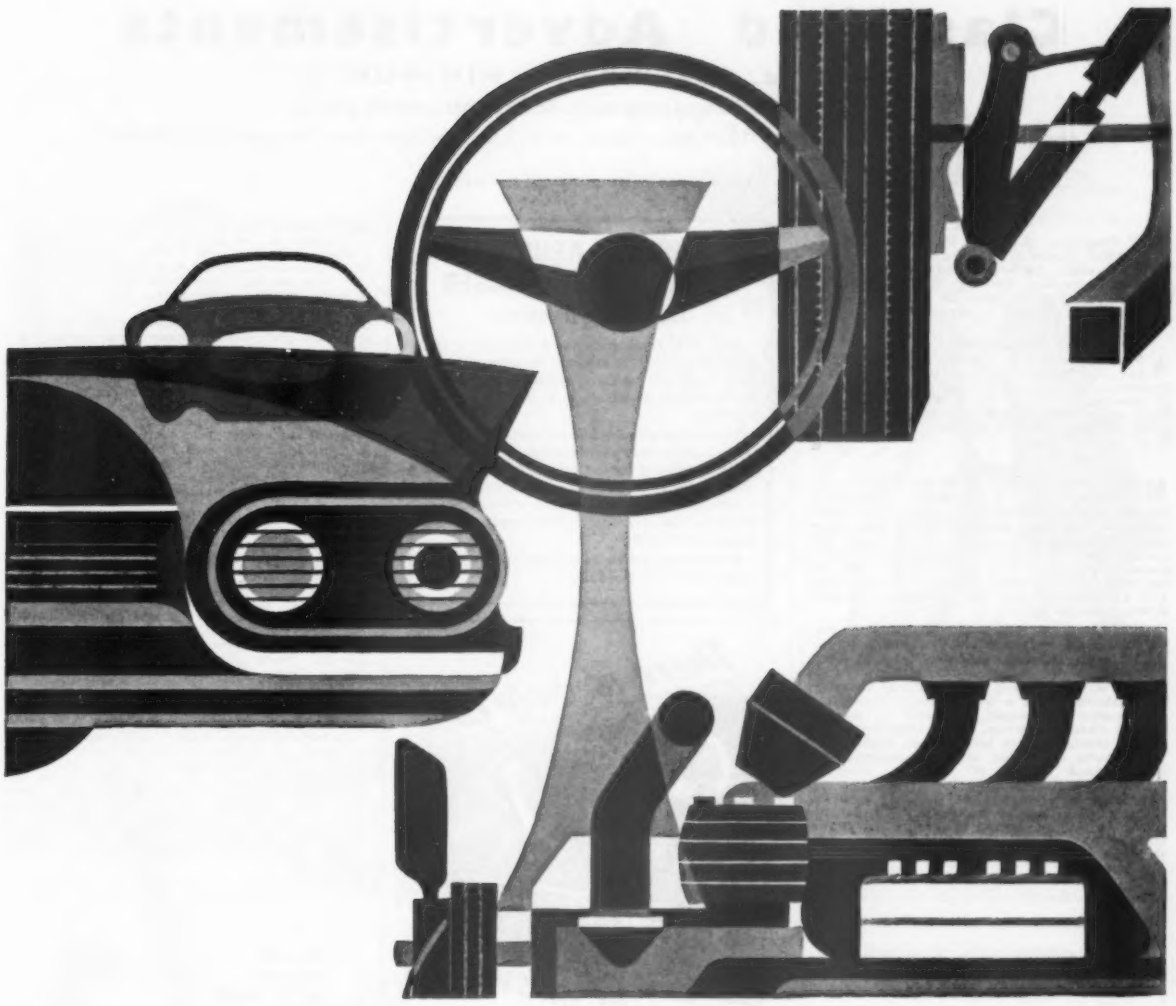
STOCKED BY LEADING MERCHANTS

SHIMWELL & Co LTD

Manufacturers since 1875

WELLINGTON ROAD · LEYTON · LONDON, E.10

Telephone: LEYtonstone 2281/3



The future of design

E.M.I. Electronics Ltd. is now working in collaboration with leading motor manufacturers on an important new aid to design engineers—the application of analogue computer techniques to motor vehicle design.

Problems concerning dynamic behaviour, such as road holding, ride and stability of all types of vehicle, are all within the scope of EMIAC II—the most versatile analogue computer available today. EMIAC II enables studies of different vehicle design features (e.g. suspension, steering, mass distribution, etc.) to be undertaken rapidly and informatively, thus readily optimising the overall design. Studies are in progress embracing all aspects of vehicle design.

Originally evolved to solve the immensely complicated problems of guided weapon design, analogue computers have proved their worth in many other fields, and EMIAC II is daily solving problems for a number of leading aircraft and guided weapon companies, chemical plant engineers, and designers in numerous industries and research establishments.

Our book "Take Liberties with Time" fully describes EMIAC II and its capabilities. Ask us for a copy now. Specific information is also available from our Analogue Computer Study Group.

EMI

E.M.I. ELECTRONICS LTD

CONTINUOUS PROCESS CONTROL DIVISION · HAYES · MIDDLESEX · TEL.: SOUTHALL 2468

EE39

Classified Advertisements

RATE 4d. PER WORD · MINIMUM 4/-

Each paragraph charged separately. Box number 5 words plus 1/-

Advertisements for the November 1959 issue should be to hand not later than first post 21st October.

(No responsibility accepted for errors)

PATENTS

THE Proprietor of British Patent No. 730291, entitled "Method and Means for Balancing Wheels," offers same for licence or otherwise to ensure practical working in Great Britain. Enquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A. [5701

TUITION

A.M.I.M.I., City & Guilds, A.M.I.Mech.E., etc., on "No Pass-No Fee" terms. Over 95% successes. For details of Exams and Courses in all branches of Auto, Diesel, Aero, Mechanical Eng., etc., write for 148-page Handbook—Free. B.I.E.T. (Dept. 643), 29 Wright's Lane, London, W.8. [5672

BOOKS

MATERIAL Handling in Works Stores 2nd Edition. By L. J. Hoefkens. Shows how the use of fork-lift trucks and pallets in industrial stores can increase production, utilize floor space more effectively, help control of movement and reduce costs. Includes a description of a system actually operated in a modern factory. 18s. 0d. net from all booksellers. By post 19s. 0d. from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

AUTOMOBILE Efficiency: Maintaining Performance with Electrical Test Equipment. By E. T. Lawson Helme, A.M.A.E.T., A.M.I.M.I. Intended for managers and operatives in the smaller service stations, this handbook describes the establishment of a modern engine tuning and maintenance department, supported by comprehensive electrical service. The various tests for tracing causes of poor performance, fault-finding in all parts of vehicle electrical equipment, a recommended system of electrical workshop practice, organization of a battery-charging service, and such matters as publicity methods, charges, operating an economical schedule of work, etc., are all covered in detail. 10s. 6d. net from all booksellers. 11s. 3d. by post from The Publishing Dept., Dorset House, Stamford St., London, S.E.1.

PERSONAL ASSISTANT TO GENERAL MANAGER

AUTOMOBILE INDUSTRY

A Vacancy arises as Personal Assistant to the General Manager for a man of the order of 35-45 years of age who has had considerable experience on Production Management in the Automobile Industry.

The successful candidate will initially be concerned with production matters but background and knowledge of the commercial, technical and sales aspects of the industry are desirable additional qualifications. The position offers excellent prospects for eventual advancement to top management level.

Applications, stating salary required should be addressed to Box No. 5224.

BOOKS

SERVICING Guide to British Motor Vehicles. Volume 4. A volume of essential data not available from any other source. Providing complete maintenance information on 40 British 1955 and 1956 cars and commercial vehicles, this book contains details unobtainable from any other publication. Based on personal research among manufacturers, it is an essential source of knowledge for every service engineer and repair man. Vol. 4 includes 22 eight-page Data Sheets concerning vehicle and engine servicing—18 four-page sheets dealing with components—new "exploded" views of all major parts—specially compiled conversion and reference tables. It will pay for itself as it speeds your work through—however few repair jobs you tackle! By post 60s. in United Kingdom only. Still available: Vol. 2—by post 44s. 6d.; Vol. 3—by post 52s. 6d. From Trader Publishing Co. Ltd., Dorset House, Stamford Street, London, S.E.1.

GAS Welding and Cutting: A Practical Guide to the Best Techniques. By C. G. Bainbridge, M.I.Mech.E., M.Inst.W. A comprehensive textbook providing practical information on almost the whole range of available gas welding and cutting equipment, methods and processes. Invaluable to the practical welder as well as to those responsible for gas welding and cutting operations involved in the fabrication and repair of industrial equipment. Price 15s. net. By post 16s. 0d. From all booksellers or from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

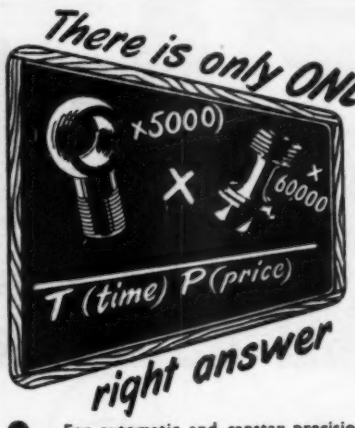
INDUSTRIAL Brazing. By H. R. Brooker and E. V. Beatson, B.Sc.(Eng.), A.M.I.E.E. The first full-length study of this subject. Covers in detail all modern brazing methods, including torch, furnace, high-frequency induction, resistance, salt bath and dip, with chapters on the special techniques necessary for aluminium, stainless steels, beryllium copper, cemented carbides and vacuum tube construction. 35s. net from all booksellers. By post 36s. 6d. from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

BONDING

Let us bond your friction lining materials to metals with modern adhesives which will withstand 300°C. We also specialise in the bonding of metals, rubber, thermo-setting plastics and wood.

- *Fully A.I.D. approved.*
- *Twenty years' experience of synthetic resins.*
- *Tell us your bonding problems and we will solve them for you.*

TECHNICAL RESIN BONDERS
Hauxton, Cambridge
Tel: Harston 573



● For automatic and capstan precision parts — in any metal — to your own specifications . . . *consult the specialist machinists.* I.F.V., D.A.I., D.I.Arm., A.R.B. Fully Approved.

REPETITION PARTS *from the* BAR *by* • • • •

Telephone: Broadwell 1115 (4 lines) and 1757

M C L

M.C.L. & REPETITION LTD.
POOL LANE · LANGLEY · BIRMINGHAM

For all types of BOLTS, NUTS, SCREWS & STUDS...
CONTACT
Samuel Marsden & SON LTD
ALTRINCHAM ST., MANCHESTER 1.

LONDON W. Kelway-Bamber & Co. Ltd., Room 7, 70, Victoria Street, London, S.W.1. Tel: Abbey 6860. **N.E. COAST** Fasteners Ltd., 2, Hall Street, Barnard Castle, Co. Durham. Tel: Barnard Castle 3172.

dm SM 46

COTTON BAGS

FOR SPARE PARTS, Etc.
Walter H. Feltham & Son Ltd
Imperial Works, Tower Bridge Road
Telephone: HOP 1784 LONDON, S.E.1

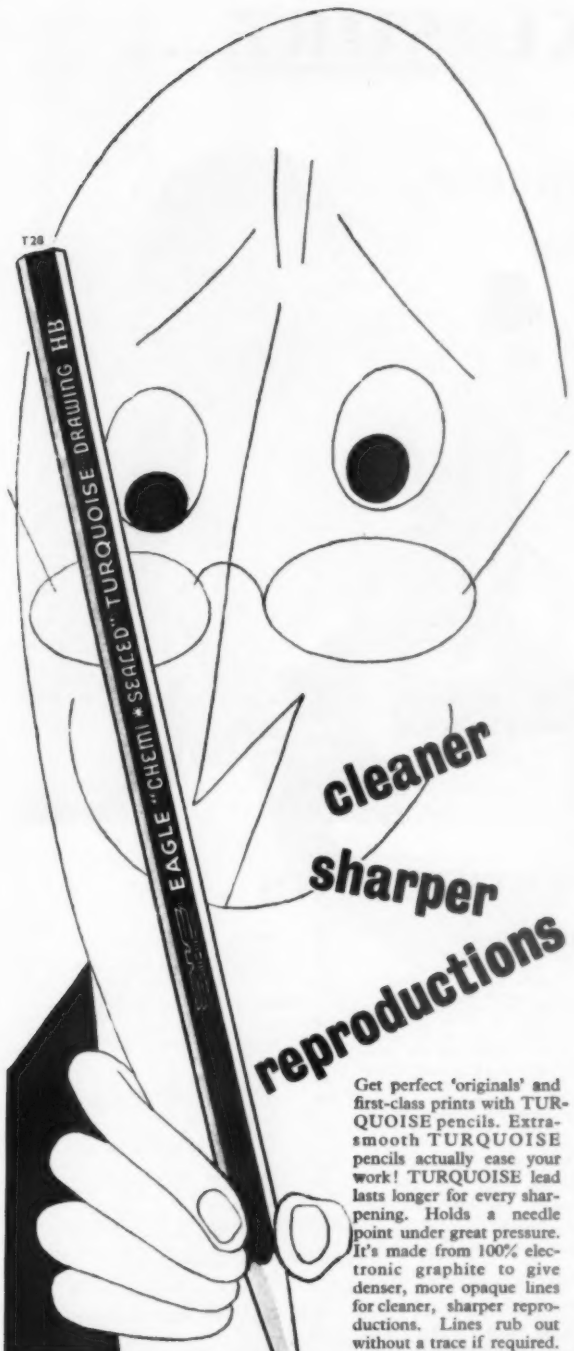
MEK-ELEK Engineering Ltd.
17, Western Road, Mitcham, Surrey.

F.J. Edwards Ltd

SHEET METAL MACHINERY · MACHINE TOOLS · WOODWORKING MACHINERY

A large range of all types IN STOCK both NEW and USED. Send for particulars.

EDWARDS HOUSE, 359-361, EUSTON RD., LONDON N.W.1
Phones: EUSton 4681 & 3771
and Lansdowne House, 41, Water St., Birmingham, 3 CENtral 7606-8



cleaner
sharper
reproductions

Get perfect 'originals' and first-class prints with TURQUOISE pencils. Extra-smooth TURQUOISE pencils actually ease your work! TURQUOISE lead lasts longer for every sharpening. Holds a needle point under great pressure. It's made from 100% electronic graphite to give denser, more opaque lines for cleaner, sharper reproductions. Lines rub out without a trace if required. No omissions, no fade-outs, no 'ghost' lines on your prints! 17 precise gradings from 9H to 6B.

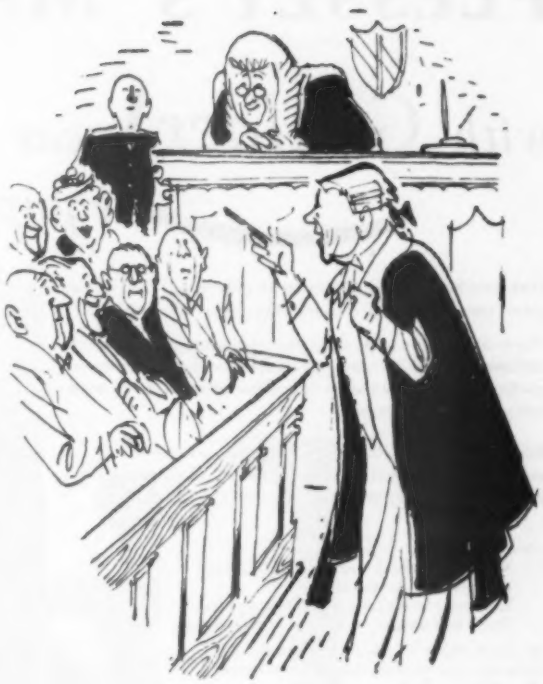
every time with

ALSO AVAILABLE!
Turquoise drawing leads 2B to 6H

TURQUOISE pencils

9d *each*
8/6 *per dozen*

EAGLE PENCIL COMPANY, ASHLEY ROAD, TOTTENHAM N.17



All the evidence . . .

. . . of laboratory investigations, confirmed by many years' experience in service, shows that anti-freeze containing sodium benzoate/sodium nitrite corrosion inhibitor is the SAFEST and most effective FOR ALL TYPES OF VEHICLES.
Wise Counsel recommends year round use of sodium benzoate/nitrite inhibited anti-freeze. The best brands contain

BUSH

Sobenite
REG. TRADE MARK

or

Sodium Benzoate

W. J. BUSH & CO. LTD · LONDON E.8 · ENGLAND
Telephone : CLIssold 1234

PLESSEY'S MAKE SURE...

with **Goulder** *gear measuring equipment*

With Goulder gear measuring equipment Plessey Ltd. find it a simple and speedy matter to make precision checks of gear measurements.

The comprehensive range of Goulder gear measuring instruments includes five types of rolling gear testers, as well as lead measuring machines and involute testers. Special machines can also be made to suit particular requirements.

Incorporating extremely high standards of accuracy and constructed from specially selected materials, all instruments are designed with the greatest attention to detail.

Checking precision ground gears on a No. 2 Involute Tester at Plessey's.

Goulders also make

Worm and wheel testers • Hob testers
Pitch testers • Sine tables
Universal beam calipers • Jigs, fixtures
Tools and gauges • Aircraft components

We shall be pleased to advise on the best method of gear measurement for your needs—just telephone or write to—

J. Goulder & Sons Ltd.

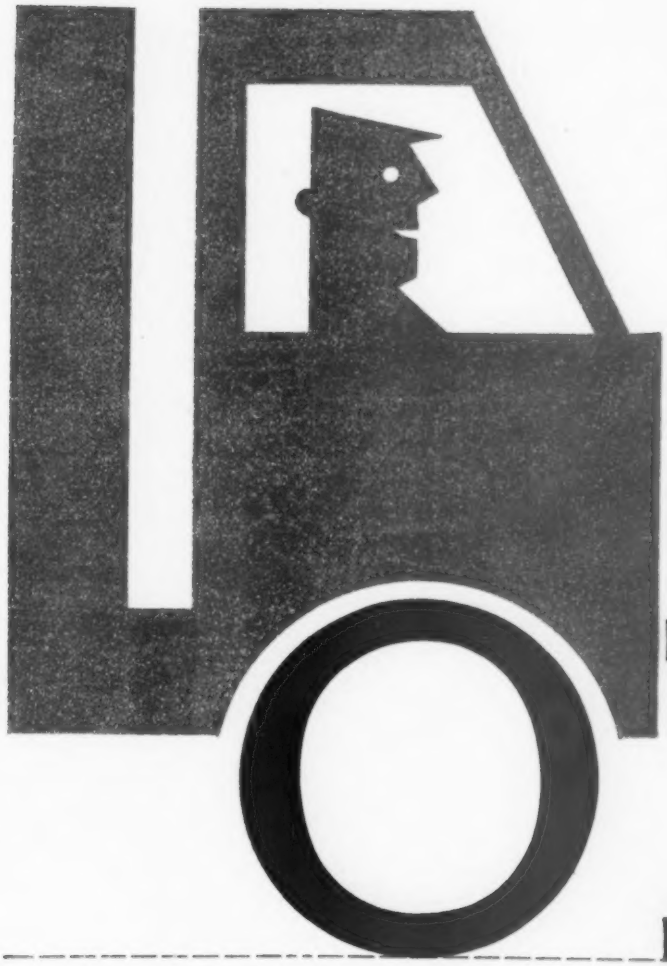
Kirkheaton, Huddersfield

Telephone Huddersfield 5252-3

INDEX TO ADVERTISEMENTS

	PAGE
AC-Delco Division of General Motors Ltd.	22
Adamant Engineering Co. Ltd.	71
Air Industrial Developments Ltd.	14
Aluminium Bronze Co. Ltd.	86
Amal Ltd.	116
Archdale, James, & Co. Ltd.	47
Armstrong Patents Ltd.	102
Atlas Copco AB	Cover ii
Automotive Engineering Ltd.	93
Automotive Products Co. Ltd.	5, 11, 12
Barber & Colman Ltd.	108
Berry, Richard, & Son	94
B.I.P. Chemicals Ltd.	24
Birfield Industries Ltd.	2, 3
Birlec Ltd.	40
Birmetals Ltd.	23
Booth, James, & Co. Ltd.	57
Borg & Beck Co.	9, 10
Bound Brook Bearings Ltd.	103
Bowaters Sales Co. Ltd.	99
Box 5224	120
B.R.D. Co. Ltd.	36
Britannia Iron & Steel Works Ltd.	94
British Monorail Ltd.	107
British Nylon Spinners Ltd.	82, 83
British Piston Ring Co. Ltd., The	63
Brook Motors Ltd.	48
Broom & Wade Ltd.	56
Bull, John, Rubber Co. Ltd.	90
Bury Felt Mfg. Co.	53
Bush, W. J., & Co. Ltd.	121
Cape Asbestos Co. Ltd., The	50, 51
Cashmore, John, Ltd.	Cover iv
C.A.V. Ltd.	52
CIBA (A.R.L.) Ltd.	34
Clancey, G., Ltd.	92
Clayton Dewandre Co. Ltd.	Cover iii
Clayton Wright Howard Ltd.	37
Coopers Mechanical Joints Ltd.	26
Copper & Asbestos Washer Co. Ltd.	90
Cross Mfg. Co. (1938) Ltd.	100
Dartmouth Auto Castings Ltd.	74
Darwins Group, The	67
Delaney Gallay Ltd.	92
Deloro Stellite Ltd.	88
Desoutter Bros. Ltd.	25
Dowty Seals Ltd.	32
Drummond - Asquith (Sales) Ltd.	59
Dunford & Elliott (Sheffield) Ltd.	116
Du Pont Co. (United Kingdom) Ltd.	38
Dupree Swift & Co. Ltd.	88
Eagle Pencil Co.	121
Edwards, F. J., Ltd.	120
Ekco Plastics Ltd.	110
Electrical Development Association	45
Electro Chemical Engineering Co. Ltd.	35
E.M.I. Electronics Ltd.	119
E.N.V. Engineering Co. Ltd.	79
Eyre Smelting Co. Ltd., The	118
Fairman Precision Tools & Products Ltd.	112
Farnborough Engineering Co. Ltd.	62
Feeny & Johnson Ltd.	116
Feltham, Walter H., & Sons Ltd.	120
Fenner, J. H., & Co. Ltd.	66
Ferodo Ltd.	64
Firth Derihon Stampings Ltd., The	72
Firth, Thos., & John Brown Ltd.	65
Firth-Vickers Stainless Steels Ltd.	105
Fry's Metal Foundries Ltd.	28
Fuller, Horsey, Sons & Cassell	104
General Electric Co. Ltd., The	96
Girling Ltd.	70
Gloucester Foundry Ltd.	60
Goulder, J., & Sons Ltd.	122
Habershon, J. J., & Sons Ltd.	100
Hardy Spicer Ltd.	58
Harper, John, & Co. Ltd.	41
Harris, John, Tools, Ltd	31
Harshaw Chemicals Ltd.	81
Herbert, Alfred, Ltd.	13, 15
Hermetic Rubber Co. Ltd.	114
Hey Engineering Co. Ltd.	104
Hoffmann Manufacturing Co. Ltd., The	77
Holroyd, John, & Co. Ltd.	101
Holset Engineering Co. Ltd.	1
I.C.I. (General Chemicals, Heat Treatment) Ltd.	20
Iliffe & Sons Ltd.	112, 114, 116
International Twist Drill Co. Ltd., The	91
Jackson, H., Ltd.	61
Jenks Bros. Ltd.	110
Kirkstall Forge Eng. Ltd.	68
Lapointe Machine Tool Co. Ltd., The	87
Lead Development Association	100
Ley's Malleable Castings Ltd.	Cover i
Lockheed Hydraulic Brake Co. Ltd.	6, 7, 8
Lockheed Precision Products Ltd.	8
Long Meadow Felt Co. Ltd.	41
Manganese Bronze & Brass Co. Ltd., The	18
Marbaix, Gaston E., Ltd.	49
Marsden, Samuel, & Son Ltd.	120
Marston Excelsior Ltd.	118
M.C.L. & Repetition Ltd	120
Mek-Elek Engineering Ltd.	120
Metalastik Ltd.	29
Metropolitan-Vickers Electrical Co. Ltd.	27
Midland Motor Cylinder Co. Ltd., The	69
Mills, Wm., Ltd.	97
Morris, B. O., Ltd.	33
Moss Gear Co. Ltd.	102
Newall, A. P., & Co. Ltd.	4
Philidas Div. of Whitehouse Industries Ltd.	42
Pitman & Sons Ltd., Sir Isaac	108
Pollard Bearings Ltd.	39
Priest, B., & Sons Ltd.	86
Ransome & Marles Bearing Co. Ltd.	43
Renold Chains Ltd.	46
Rockwell Machine Tool Co. Ltd.	108
S. & D. Rivet Co.	114
Salisbury Transmission Ltd.	111
Salter, Geo., & Co. Ltd.	16
Saunders-Roe Ltd.	78
Schrader's, A., Son	73
Sheffield Twist Drill & Steel Co. Ltd., The	17
Shell-Mex & B.P. Ltd.	85
Shimwell & Co. Ltd.	118
Silentbloc Ltd.	21
Simms Motor Units Ltd.	117
Skefko Ball Bearing Co. Ltd.	76
Smith, C. & B., Ltd.	96
Solex (Gauges) Ltd.	19
Speed Tools Co. Ltd.	106
Steel Co. of Wales Ltd., The	109
Sterling Metals Ltd.	44
Super Oil Seals & Gaskets Ltd.	89
Technical Resin Bonders	120
Terry, Herbert, & Sons Ltd.	113
Torrington Co. Ltd., The	95
Triplex Foundry Ltd.	112
Turner Bros. Asbestos Co. Ltd.	115
Turner Machine Tools Ltd.	106
Udal, J. P., Ltd.	98
Van Moppes, L. M., & Sons (Diamond Tools) Ltd.	54
Vaughan, A. J., & Co. (Mitre Works) Ltd.	108
Vaughan Associates Ltd.	84
Ward, Thos. W., Ltd.	55
Wellworthy Piston Rings Ltd.	80
Wild-Barfield Electric Furnaces Ltd.	30
Wiley, James, & Son Ltd.	98

Printed in Great Britain for the Publishers, ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1, by James Cond Ltd., Charlotte Street, Birmingham 3. "Automobile Engineer" can be obtained abroad from the following: AUSTRALIA & NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service Ltd.; Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd.; Wm. Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Co. Entered as Second Class Matter at the New York, U.S.A., Post Office.



Oil

...in the right place

...at the right time

...that's the secret of successful chassis lubrication. And it's the ability of the Clayton Dewandre Automatic system to do just this that makes it an all-the-way winner... especially if fitted *right from the start* when ordering a new vehicle. C.D. Automatic Chassis Lubrication goes right to the heart of the problem. A constant supply of oil is pumped to all the vital points while your vehicle is *on the road*, saving oil *and* maintenance time. This supply through individual pressure-feed lines extends the life of each bearing by up to *ten times!* That's why over 60,000 Clayton Dewandre lubrication systems are now in daily use... why Clayton Dewandre have a reputation of pre-eminence in the field of road vehicle equipment.

Write for descriptive leaflet

- No further cost after installation—system lasts life of vehicle.
- No maintenance required—just keep the reservoir topped up.
- 24 or 36-point automatic systems available for short-run vehicles.
- 24 to 72-point mechanical systems for long-distance vehicles.

CLAYTON DEWANDRE CO. LTD.

AUTOMATIC CHASSIS LUBRICATION

TITANIC WORKS . LINCOLN . ENGLAND . TELEPHONE: LINCOLN 25272

L27

"... but STAINLESS STEEL CHEAPER this way!"

"Cashmores hold the stocks and carry the financial burden—whilst I use valuable floor space for production. And, what's more, there's no need for me to worry about losses on redundant stock.

"With their new TELEX service and speedy delivery fleet you can say Cashmore's stocks are my stocks—and that's why it's cheaper all round!"

A call to CASHMORES brings STAINLESS to your doorstep—in bars, flats, hexagons, sheets or plate, to specifications in general use.

CASHMORES

JOHN CASHMORE LIMITED

GREAT BRIDGE · TIPTON · [illegible]

Telephone: TIPton 2181/7 Telex: [illegible]

London Office: Artillery Mansions, 75 Victoria Street, London, S.W.1. Telephone: [illegible]

SM/JC.4247/SS